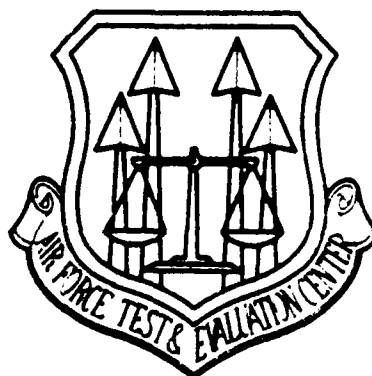


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# LOGISTICS COMPOSITE MODEL (LCOM) WORKBOOK

AIR FORCE TEST AND EVALUATION CENTER  
KIRTLAND AIR FORCE BASE  
NEW MEXICO 87117

JUNE 1976

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Logic networks are demonstrated and lead into user procedures which, upon completion of the simulation run, result in a manpower unit detail listing. Operational test and evaluation applications are discussed with instructions for use. A series of working appendices are provided to assist the user.

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## PREFACE

This workbook is designed to assist the AFTEC analyst in organizing his effort in use of the Logistics Composite Model (LCOM). It is based upon AFLC Reports 70-1, 74-1 (Drake) and AFHRL-TR-74-97 (II, III, IV, V, VI) Tetmeyer, Moody, Nichols, Hicks).

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This LCOM workbook was accomplished in response to AFTEC requirements by R/M Systems, Inc. under subcontract to the BDM Corporation. This document was prepared by Richard S. Robinson with assistance of Mr. Lewis P. Gaby II and Miss Rebecca Hunter for specific portions of the workbook. Lt. Col. Donald C. Tetmeyer was most generous in his advice and contribution of manuscript. Mr. William F. Drake graciously assisted in the basic technical content and organization. Capt. Royce C. Kennedy developed the Expected Value Model and contributed it toward the workbook. Contributions from the following Air Force personnel for technical inputs and manuscript review are appreciated.

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# AFTEC LCOM WORKBOOK

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## I. INTRODUCTION

Determination of maintenance manpower requirements has always been a difficult task. The initial maintenance manpower determination for a new weapon system has been provided by the contractor through the Quantitative, Quantitative Personnel Requirements Information (QQPRI). The QQPRI was developed after the design tradeoffs had been accomplished and was usually based upon fixed assumptions which were not responsive to the dynamic missions of the Air Force and limited to hands-on or corrective maintenance tasks. The QQPRI also failed to recognize the manifold tasks associated with the complete maintenance action. It also lacked flexibility, because only a single phase of a scenario was faced in its computation of manpower requirements.

Identification and forecasting of maintenance manpower requirements during testing under variable mission scenarios is a vital yet difficult task. Mathematical simulation has been identified as the best method to solve this requirement for new weapon systems. LCOM fulfills the simulation task since it permits the user to define a realistic operational and logistical scenario. LCOM is a most versatile and flexible data processing tool which permits the user to vary the operations, maintenance, and supply data inputs to test a given capability. Impact of changes to design configuration, type of sortie, maintenance policies and concepts, and spares levelling can be readily assessed and updated as additional data are obtained, making LCOM a dynamic simulation model.



## II. LOGISTICS COMPOSITE MODEL

A. The LCOM model was developed as a composite of three individual models or programs. A most significant feature of the LCOM system is that programs communicate with each other with limited assistance of the user. All of the LCOM programs, preprocessor (input), main (simulation), and postprocessor are written in Simscript I (see Fig. 2-1). A Simscript II version is scheduled for implementation in August 1977.

1. Preprocessor Program - The preprocessor program provides a translation service by reducing the expanded data from input forms to a machine usable format. It also serves as a sortie generator which exercises both the operational and logistic systems of the scenario.

2. Main Program - The main program consists of the simulation model. The logic in this model, combined with the data inputs representing the operational scenario, weather limitations, and logistical assets, permit the simulation of the support response to the flying schedule. This program provides data in terms of a weapon system and parts failures which correspond to reliability data, processing maintenance tasks necessary to correct the discrepancy, use of logistic resources and interaction of the logistic resource availability in the demand process.

3. Postprocessor Programs - LCOM provides multiple postprocessor programs ranging from time series graphs of output statistics pertaining to a particular aircraft to a series of manpower matrices. The Manpower Matrix Program provides printouts for on-equipment manpower demands, off-equipment manpower demands, on-equipment manpower backorders, and off-equipment manpower demands. The program can reflect actual demand for manpower (in one-half hour increments) for each given manpower specialist, or provide summary statistics as to workload and/or crew size. The latter program is in prevalent use while the former programs are rarely used.

B. Data Collection/Development - To support the basic LCOM model, the data development phase is necessary (see Fig. 2-1). This phase includes the identification of data sources and the use of several data processing programs to collect and integrate the basic raw data, and provides the necessary step to insure a total LCOM simulation. Basic data are collected either through the Maintenance Data Collection System (MDCS) worldwide, resolved into the K-97 Report, the D056 series, or from test data through the AFSC Forms 258 and 325. Comparability analyses are conducted from these data to determine probable failure rates, task times, crew sizes, etc. The LCOM Extended Form 11 is completed with these data to denote task description, associated resources, task duration, priority and task type.

C. General Description of the LCOM Model

1. Preprocessor - Input Model

a. The purpose of the input model is to translate user input data to a form suitable for use in the main LCOM model and serve as a sortie generator (see Fig. 2-1). The user collects the input data, develops networks, records the data on appropriate LCOM forms which are punched to form the input data deck. Appropriate job control cards are used to enter the card deck into the computer system. (See Appendices O and P.) The input deck, less the Form 20 Sortie Generation Data, is edited by the preprocessor and converted into the initialization deck. Simultaneously, error checking is performed and an edited listing of the input deck is printed.

b. Diagnostics are provided as a result of editing the input data and discovering data inconsistencies. Should limited ambiguities be discovered in the input data an assumption will be made by the preprocessor and an error message will be provided with the assumption to preclude the loss of a run.

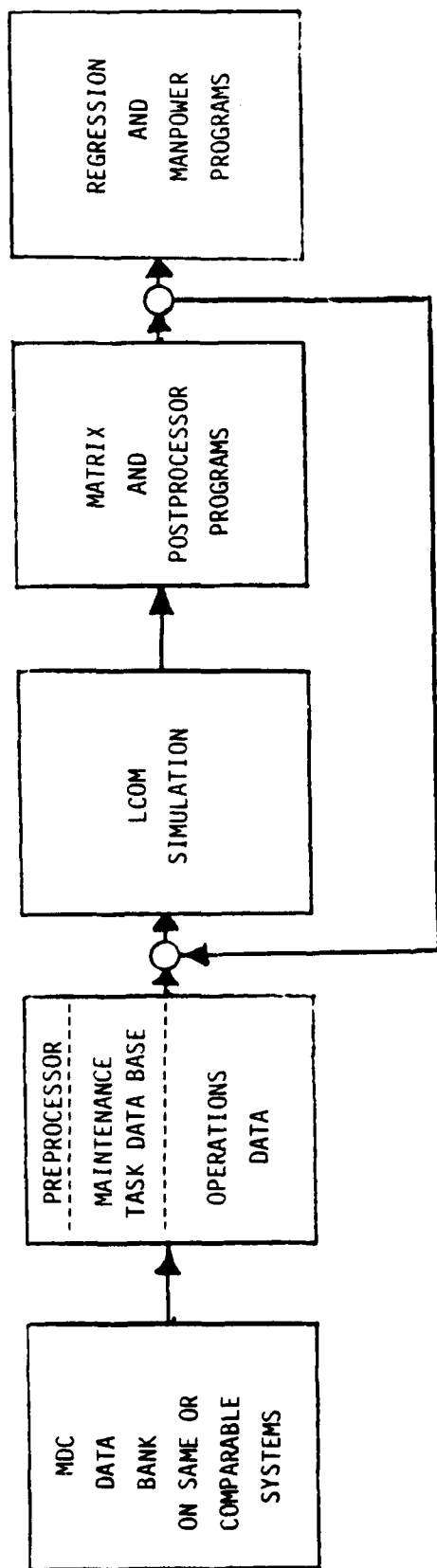


Figure 2-1. Model Development and Operation.



For example: Should an illegal selection mode type be inserted on Column 9 on LCOM Form 11, the input model assumes this task to be a "DO" task. Message number 37 is printed as, "INVALID SELECTION MODE - ASSUME D (INPNET)." As a corrective action you may insert the proper selection mode if "DO" is unsatisfactory, and rerun the preprocessor. Of course, there are cases wherein an assumption could not be made and the run will terminate. i.e., should no Form 17 data be entered, the network cannot be processed. The message printout will state, "NO MISSION ENTRY POINTS HAVE BEEN SPECIFIED. (CHECK.)." The corrective action would be to complete Form 17 data for the designated mission types and the necessary connecting task networks (Form 11) and rerun the preprocessor program.

c. Errors that are undetectable by this input program fall into categories such as network logic errors, use of wrong (but not illegal) resources on various tasks, incorrect parameters, and other not illegal but definite errors. Reduction of these types of problems and errors is one of the goals of this workbook development effort. Machine data audits do not cover the entire range of possibilities but are a valuable asset in covering a wide range of possible errors. Descriptions of the data audits are covered in detail in LCOM Users Reference Guide Update, AFLC/ADDR Report 74-1, November 1974.

d. In the next phase, the Form 20 Sortie Generation Data are edited and an exogenous tape of events is produced--in essence, the sortie scenario for the entire simulation. Separate runs of input-sortie data may be run if desired. Reformatted data from the input model are used in the simulation, postprocessor (matrices) models. The relationship of inputs is demonstrated in Figure 2-2.

(1) Outputs of the Input Model

The three outputs of the input model are:

- (a) Exogenous tape
- (b) Simulation model initialization tape
- (c) Output listing of input data

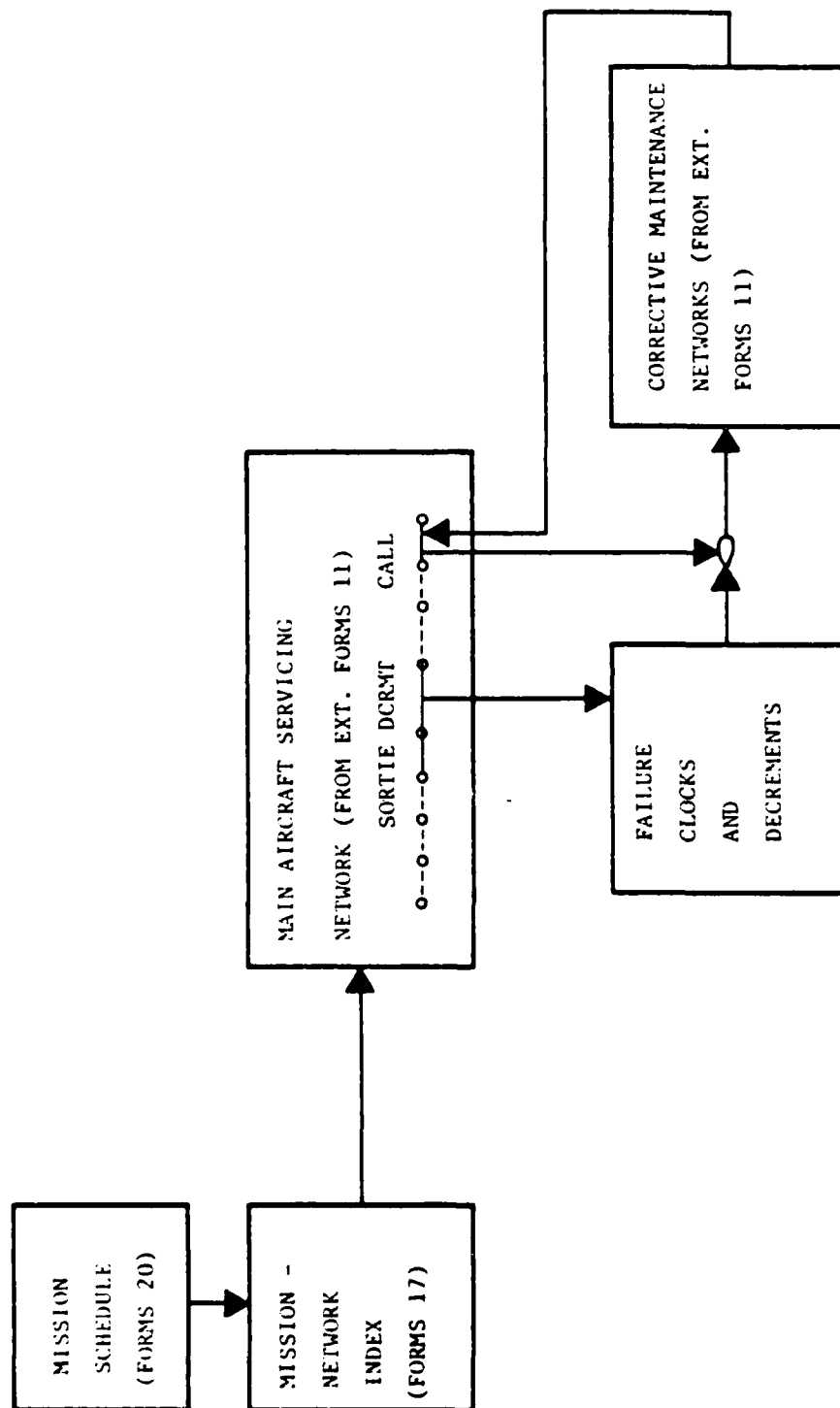


Figure 2-2. Relationship of Inputs.

The output listing will include expanded listings of the processed cards, diagnostics or warnings (see AFLC Report 74-1), listings or warnings at the end of each group of forms, a set of dictionaries, and a control table listing.

e. Simulation Model - The simulation model is designed to represent a broad range of aircraft operations, scheduling, maintenance and supply functions at an Air Force base. In accordance with the LCOM design objectives, the logical ordering of actions within the model may be adapted to any problem situation and therefore must be specified by the user for his specific application. The user is free to define both the resources of interest and the manner of their intended utilization, while the model provides the necessary controls and structure to simulate and maintain a record of their action and interaction.

**CAUTION: LIMIT THE DEFINITION OF THE PROBLEM TO ONLY THE  
NECESSARY LEVEL OF COMPLEXITY!!**

During the course of the simulation various types of missions are scheduled, based upon operations data provided by the user. For each mission requirement, the simulation model controls the processing of each aircraft towards the completion of the mission through any maintenance which may result from the mission. This characteristic is illustrated in Fig. 2-3. As in real life, the model attempts to complete all missions, but aborts those missions which cannot be completed as scheduled. Actions which could cancel a mission might be the availability of sufficient aircraft to schedule into pre-sortie tasks, the lack of sufficient aircraft due to failures directed in pre-sortie tasks that cannot be completed prior to the sortie time, or the loss of ready aircraft to missions of higher priority.

After the mission is completed, the aircraft undergo post-sortie maintenance as specified by the user. Normally included in post-sortie maintenance are debriefing and troubleshooting tasks in which aircraft system failures are detected and their correction begun. This phase of the simulation also

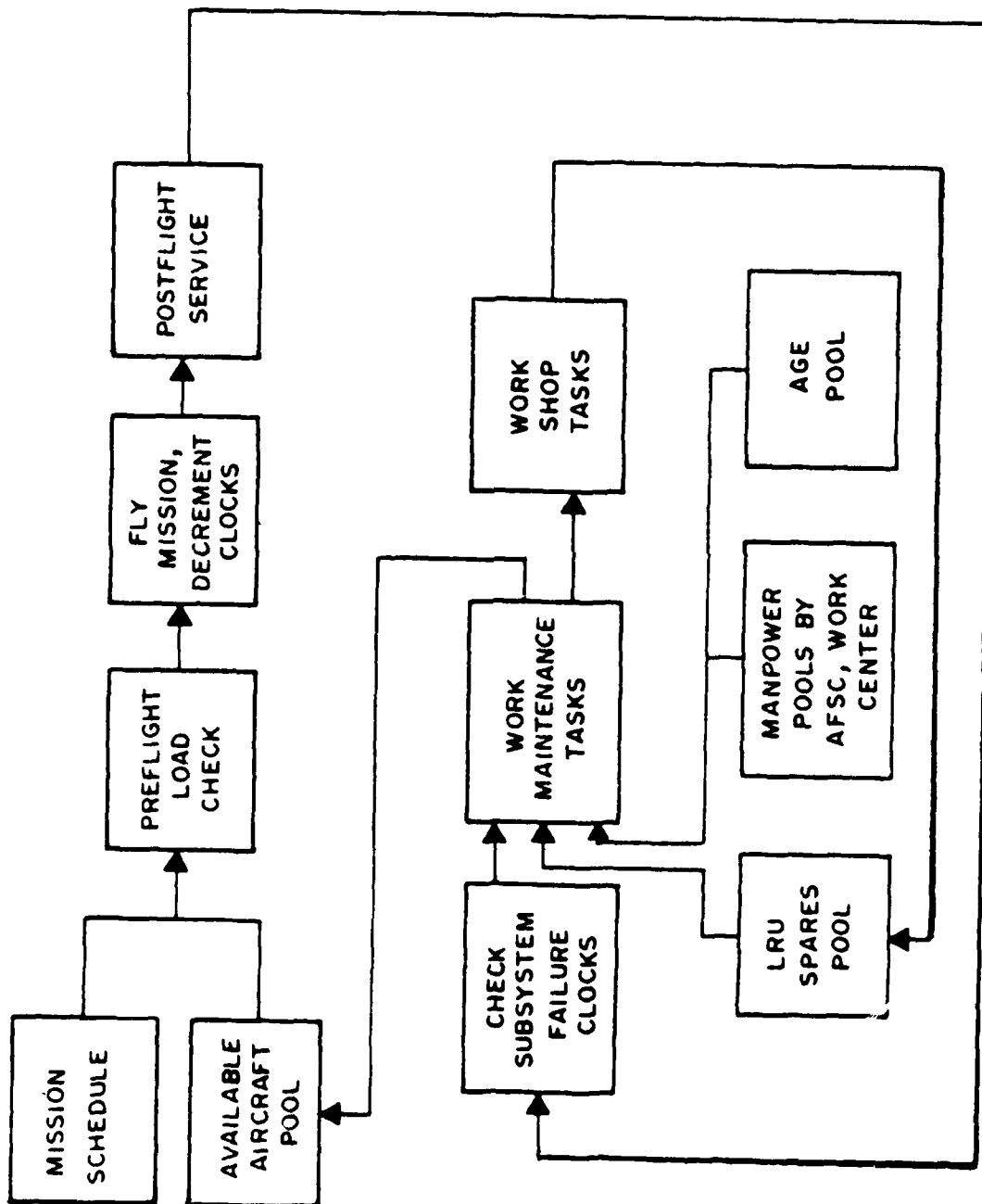


Figure 2-3. How the Simulation Model Works.

generates the demands for spares from supply, and simultaneously generates reparable assemblies for maintenance in one or more of the base repair shops, or in the case of NRTS (Not Repairable This Station) items, the depot-level repair facilities.

Maintenance at this point follows two distinct paths: one for the aircraft itself (flight line maintenance) and one for the reparable assemblies (shop maintenance). Flight line maintenance normally consists of those tasks required to troubleshoot and remedy failures either by repairing the items on the aircraft or by replacement of faulty items with serviceable spares. After all aircraft maintenance is completed, the aircraft is returned to a serviceable pool, or if the maintenance was required for preflight leading to a mission which is still valid (scheduled), the aircraft is contained through its pre-sortie tasks.

Shop maintenance tasks are those base or depot tasks required to troubleshoot the reparable assembly and remedy the failure by repair and/or replacement of one or more of its first indenture assemblies, followed by some functional test. After replacement, a second indenture reparable may be generated for further base or depot maintenance. This method of sub-indenture failure generation can be repeated down to any level and is dependent only upon data availability and computer storage capacity. For each indenture, maintenance is accomplished in the same manner as described above. Individual reparable items follow either their own maintenance tasks as described by the input, or a general abstracted set of maintenance tasks, as might be the case at the lowest indentures being studied.

Whether to repair an item at base or depot is a selection based upon the input NRTS (to depot) percentage for that item. In each case, as with flight line or intermediate maintenance, the repair follows a specific set of tasks. For depot maintenance, this set of tasks can be described as a single task representing the depot order and shipping time. Upon completion of the designated tasks at either base or depot, the unit is returned to base supply as a serviceable item and appropriate stock levels are incremented.

A shift mechanism within the simulation model permits specific resources such as personnel to be utilized on a shift basis as designated by the user. This mechanism is flexible in that any number of shift policies can be utilized at one time. Resources need only be designated as working or operating under a specific policy. At appropriate shift levels these resources are incremented or decremented as required.

Statistical data are generated by the simulations collected and summarized during the entire operation of the model. At specific simulation times, designated by the user, results can be reproduced in output formats for analysis. A schematic of how the simulation works is shown in Fig. 2-3.

(1) Outputs of the Simulation Model:

The Simulation Model will produce the following reports:

- (a) Performance Summary
- (b) Resource Status
- (c) Mission Status
- (d) In-Process Status
- (e) Backorder Status
- (f) Control Table Hit Count
- (g) Diagnostic

A performance summary is automatically produced at user specified simulation time intervals, while the remaining reports are produced on demand. All of the demand reports require substantial computer time and can produce great quantities of paper if used too frequently.

g. Postprocessor Program

(1) A third major program is the postprocessor program, which provides times series graphs of the output statistics and plots of the tasks related to a particular aircraft. The data for this program are recorded on magnetic tape by the Simulation Program and are available for processing on demand by the user. The postprocessor graphs depict performance, its change; and

comparison between related items such as backorder rate and supply fill rates; base or depot. The graphical representation also provides a visual check as to whether or not the networks are working as desired, however at the present time these functions are rarely used.

(2) LCOM is capable of producing and manipulating great quantities of data and literally produces, in the case of the Simulation Model, a full scale accounting of all missions, configuration changes, inspections, jobs and resource utilization over a simulated time period resulting in a mass of data that would stagger the user. To preclude this possibility, LCOM was designed with 65 aggregate performance statistics within preselected systems, subsystems, speciality code or equipment grouping. It is vital that data collected from these groups represent meaningful averages in sample sizes and times, otherwise, the collected statistics could result in unusual random draws made by the mathematical algorithms.

CAUTION: RUN THE SIMULATION LONG ENOUGH TO GET MEANINGFUL SAMPLES !

For the reasons given above, only summary reports are produced automatically at users schedule, i.e., Performance Summary Report. At the user's option, a Resource Data Listing at preselected times can be obtained and used to cross check input data to assure completeness. The Resource Data Listing can be a distinct advantage in tracking a consistent out-of-line statistic in the Performance Summary Reports. This report can also help identify the faulty input data elements. Each submodel has its own output reports which are identified in AFLC Report 70-1 as to whether they are automatic or demand reports. The column heading identification algorithms are currently being revised which should be most helpful to the user when fully implemented.

### (3) Manpower Matrices

a. Figures 2-4 through 2-7 provide examples of the Manpower Matrix Program for on-equipment manpower demands, off-equipment manpower demands, on-equipment manpower backorders, and off-equipment manpower backorders, respectively.





OFF EQUIPMENT MANPOWER MATRIX FOR WORK CENTER CONSOLE ( 7 ) THIS MATRIX COVERS										9 DAYS OF SIMULATION DATA									
NUMBER	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43
OF																			
PEOPLE																			
WORKING 28																			
15																			
18																			
5																			
12																			
2																			
3																			
23																			
6																			
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FIGURE 2-5. OFF EQUIPMENT MANPOWER MATRIX

FIGURE 2-6. ON EQUIPMENT BACKORDER MANPOWER MATRIX





This program reflects actual demands for manpower (in one-half hour increments) for each given manpower specialty. In addition, summary statistics relative to the workload and/or crew size are provided.

There are four types of manpower matrices available. Each report consists of a time-oriented display along with statistics about each type of maintenance resource. Figure 2-4 is an example of the ON-Equipment matrix for resource OMPERS. Normally there is an associated OFF-Equipment matrix for the same resource. The example shown in Fig. 2-5 is the OFF-equipment matrix for a different resource. In each of the manpower matrices there are 48 columns, each representing one-half hour of the day. The numbers in each column sum to the number of days the manpower matrix was on. The sums in Figs. 2-4 through 2-7 will equal 9 since these matrices are from a nine-day output run. The values in the columns represent the number of days for a particular half hour that the number of people indicated on the left margin were working. For example, the 6 (circled) in the matrix Fig. 2-4 shows that on 6 of the 9 days, between 0800 and 0830, there were 3 of these OMPERS resources working.

The ON and OFF equipment matrices serve two main purposes: (1) If the matrix is from a simulation with an excessive number of authorizations for the resource (i.e., unconstrained), then the peaks in the matrix graphically depict the peak workload for that resource. Then by weighting the relative criticality of ON and OFF equipment work, and by looking at the ON and OFF equipment peak demand pattern by shift, the user can determine what a reasonable authorization level for that resource should be; (2) When the matrix is from a run constrained with the predetermined levels, the matrix can be used to evaluate how well these levels performed. For example, in Fig. 2-5 where there were four COMSPL resources authorized on the first shift, the top row (5th row) in the matrix for this shift shows how often that the 4th authorization was working. As can be seen (circled) during each of the first seven 1/2 hour shifts, for 2 of the 9 days, all 4 COMSPL resources were in use. Figure 2-8 is another manpower matrix presentation for a work center for 90 days.

Besides the two ON and OFF equipment matrices and the Performance Summary Reports statistics on manpower resources, there are two additional matrices to help evaluate the adequacy of an authorization level, the Backorder ON and OFF equipment matrices (see Figs. 2-6 and 2-7). The main difference between the Backorder and the manpower matrices is that the backorder matrices show number of authorizations short instead of number working. The statistics in the four matrices are self-explanatory. The two most useful statistics are the hours of delay by shift on the backorder matrices along with the max crew size from the manpower matrices. To prevent bottlenecks in the simulation, the user should always have, at least on one shift, the "max crew size" or more authorized for each manpower resource.

#### (4) Regression Program

To get a full complement of outputs for manpower planning, it is only necessary to simulate three flying hour schedules for each of three different organization sizes and obtain a set of regression cards for each unit size. The use of the regression and manpower programs permits manning for a range of flying schedules to be quickly obtained from the simulation of three consistent points. The simulated hours scheduled or flown on any of the three scenarios do not have to match the flying hours scheduled, but should be within the same range. This procedure has the further advantage of assuring an optimum scheduling since output for any given scenario can vary with the percent of aircraft scheduled over and above the target flying schedule and results seldom hit exactly on target. By redefining the flying hours achieved as the scheduled flying hour schedule for input to the regression program, overschedule becomes an output of LCOM and is consistent through the range of the regression equations.

The regression and Moody manpower programs eliminate the need for any additional expensive LCOM simulation runs to determine the impact of alternative flying schedules, provided other scenario assumptions remain constant. However, a change in these assumptions does not necessarily require a complete LCOM rerun. The regression program also includes an

option for proportionate shifting of direct manning equations based on the simulation of one new point. The example curve continues to pass through the same origin, as shown in Fig. 2-9.

The curve shifting feature is particularly useful for sensitivity testing, since all results can be brought back to the same manning baseline. This technique is applicable for most changes where manning is determined from the constant or manhour derived curves which are known to be nearly linear. Curve shifting should be used with caution when extrapolating manning on portions of the curve that are matrix determined, since the general shape of peak demand functions is not yet well defined. Neither does this feature eliminate the need for periodic updates of the scenario and data base.

The method of shifting curves in the regression program is explained in AFHRL-TR-74-97(V).

(5) Realized Flying Schedule Postprocessor System - This system analyzes the realized flying schedule (simulated flying schedule) through a series of five programs known as: RFSPROC, TACFLIER, TAILSCAN, RFSANAL and TALLYHO. These programs combine records, print a block preflight report, analyze aircrew ratio requirements, search for tail numbers, produce traces of aircraft through simulation and provide a daily analysis of sortie accomplishment of for each mission type for both possessed A/C and unscheduled A/C.

(g) Interface with Other Models.

(1) LCOM may be used in support of the Cost of Ownership Model (COO) in the development of manpower costs for crew ratios, maintenance manpower, and the adequacy of replenishment spares. In the case of crew ratios, the command policies relative to crew duty times, DNIF probabilities, whether

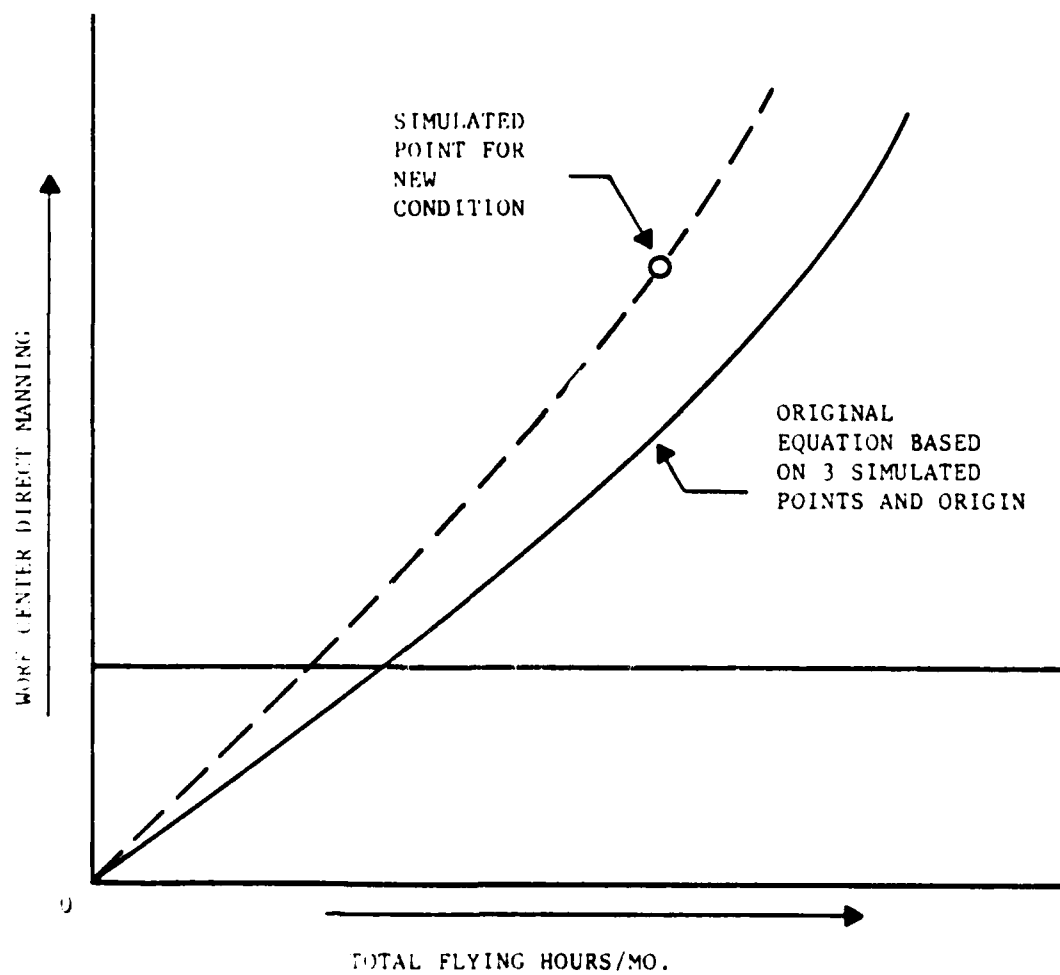


Figure 2-9. Curve shifting.



formed crews are required, multiple seat qualification, flight lead or special qualifications, squadron integrity, days-off policy, and downed crew recovery rate must be considered in the scenario for the LCOM run for application to the COO. Maintenance manpower considerations must be provided for in terms of manpower available, direct versus indirect labor, skills available, shift manning requirements for direct manning requirements and indirect tasks. Another allowance which must be considered is for the calibration of shop equipment within the avionics maintenance squadron which provides for those items not calibrated by PMEL. In the replenishment spares area the interface for COO will be the computation of spares consumption. Both LCOM and METRIC, a spares computation model, require the unit cost of a line replaceable unit/shop replaceable unit (LRU-SRU), thus a compilation of cost is available from the Forms 13.

(2) Optimum Repair Level Analysis (ORLA) may also interface with LCOM in the area of workload generated in shops for repair of LRUs or SRUs at base level. LRUs should be identified in the input data for base level repair or evaluation for depot repair as this will impact both the maintenance manpower and the supply system.

(3) LCOM also has an interface with both the COO and the Mission Completion Success Probability (MCSP) model in the area of maintenance materiel. Equipment is identified as a resource and thus becomes an item of cost for COO and a possible mission limitation for MCSP.

(4) LCOM and MCSP can be used jointly in design tradeoff studies in emerging systems and also for subsequent Class IV and Class V modifications. For example, a study may be conducted using MCSP to identify a component that needs modification and then run LCOM or EVM to determine the effect of the change.

h. LCOM Limitations - LCOM, as a working tool, has limitations that the user must be aware of in order to use it effectively. Among its limitations are:

- (1) Computer storage limitations are variable with the type of computer equipment used and is a critical factor in determining the size of an LCOM simulation. You should make a core count and reduce it to the minimum possible when planning a LCOM scenario.
- (2) No generalized decision method exists which permits one task to be contingent upon another. Thus the user must determine through a failure resource mechanism (halt clock) as to the probability of a route. Network trickery, or skill and experience in networking, is a means of coping with this problem.
- (3) Only a sortie task is permitted to be designated for external control, i.e., takeoff time.
- (4) LCOM fails to provide a measure of accuracy for a pause between the act of generating the airplane for the sortie and the next step of the problem, the aircrew preflight. This is an external scheduling limitation.
- (5) LCOM cannot defer maintenance until a time block becomes available. If implemented this feature would be extremely expensive in terms of computer storage usage. The deferred maintenance is accomplished by waiting until the phase inspection is accomplished by picking it up in the look-phase of the inspection.
- (6) An LCOM simulation is time consuming in terms of both calendar time and manpower effort.
- (7) LCOM cannot measure mission success.
- (8) LCOM's assessment of battle damage, depot actions and maintenance on AGE is either extremely limited or nonexistent.

### III. LCOM PLANNING

Planning for a successful LCOM simulation is a basic prerequisite for the analyst.

A. Authority - Authorization for an LCOM simulation is necessary and in the case of AFTEC should be an element of the test plan. The Air Staff agency, AFPRM, will provide the basic authority for manpower studies. AFTEC may require a study to be conducted within its own authority.

B. Administrative Details - Coordination is the key to success in precluding embarrassing omissions in the LCOM Plan. Communicate with all of the participating agencies initially by phone and finally with letters which clearly establish each level of responsibility for the participants. To insure command support and intracommand cooperation a briefing would be desirable delineating the objectives, time-frame of the study, participants and their roles, support required, site of study, etc.

C. Weapon System Familiarization - Basic familiarization with the system to be modeled is essential for the analyst to assure a complete and functional LCOM Plan. His study should include both the operational as well as the logistical aspects of the problem. Among items to be studied in planning preparation are:

1. Operations Concept - The operations concept is discussed in some detail, with data sources, in Section IV.

2. Maintenance Concept - The maintenance concept is discussed in some detail, with data sources, in Section V.

3. QQPRI/AFSC-SPO Documents - These are source documents giving first cut information as to the initial values for manpower. These documents currently are not used for aircraft, but may be used for electronic systems.

4. AFM 66-1, Maintenance Management - It is essential that the analyst be familiar with the maintenance organization and operations in order to fully appreciate the maintenance concept.
5. T.O. 00-20-2 is the AF source document for the Maintenance Data Collection System (MDCS) and provides the detailed information necessary to collect and report maintenance data via the AFTO Form 349.
6. The Dash Six technical order for the weapon system delineates scheduled inspection requirements, i.e., T.O. 1F-105D-6.
7. The Work Unit Code Manual describes the maintenance codes used to portray maintenance data, i.e., T.O. 1F-105D-06.
8. War Mobilization Planning Documents (WMP) - Six planning factors provide basic information on usage, attrition, consumption rates, etc. This document's importance cannot be overstressed for planning combat situations.
9. NORS rates are a major constraining item in planning the simulation. A coordinated response is needed from the DO and LG to preclude a breakdown of the later acceptance of the product. Should that position be unattainable from either the LG or DO, then use of the DOD Standard of 5% NORS could be assumed and made part of the published assumptions for the study.
10. Program Estimating Equation (PEE) - Points are selected to represent the various sortie rates to be flown by the weapon system in contrast to those specified in the WMP-6. The PEE coupled with the WMP-6, in effect, establish an upper and lower limit around the specified sortie rates for the stipulated UEs.
11. Deployment Concept Must be Specified - AFM 28-40 and WMP documents related to deployment concepts should be studied for applicability.

12. The abort effect must be studied. Rates must be agreed upon between the DO/LG staffs.
13. An alert posture must be included in the scenario.
14. Aircraft configurations and changes thereto become a driving force in the capability of maintenance to support the operational mission. Substantial discussions with maintenance personnel familiar with the system is recommended.
15. Conflicting maintenance, such as fuel cell repair and power on avionics maintenance cannot be done simultaneously. If significant maintenance conflicts can be identified, then the standard type of networking will work. The conflicting tasks may be done in sequence or groups of tasks may be done in parallel. The chances of certain parallel tasks occurring together and requiring two people in the cockpit are remote and are not considered.

#### IV. SCENARIO

The operational-logistical scenario has a direct impact on the entire LCOM problem for it dictates the mission requirement, the resources, sortie rate and the time frame. By varying those factors you may change the problem slightly or greatly. Limiting the mission reduces requirements while conversely the expansion of the mission increases requirements. A reduction in resources would require a higher utilization to accomplish the mission or a change in sortie rate and/or sortie length could change resource requirements. Similarly, a time frame change could alter the outcome of the problem by compressing the activity into an unacceptable level or expanding it into a dragged out situation with minimum utilization with resultant manpower loss. The scenario flying activity will create the exogenous events file for LCOM.

Both operations and logistics are major elements of the LCOM simulation scenario and each must be carefully described or the outcome of the simulation will be in error or skewed. There is a tendency to make a scenario that is more complex or extensive than necessary to achieve an objective; limit the problem as much as possible! Granted, it may be difficult to get an agreement on the specific mission requirements; however, you must get them agreed upon by the decision makers and the ultimate using organizations, or the results will probably be discarded and your effort wasted. Since few aircraft have only a single mission capability, the operations scenario must reflect its versatility and be appropriate to decisions and plans that will be made and used with the model results. Check with the requirements office in the using command for their operational concept and contact the Deputy Chief of Staff for Logistics for the maintenance and support concept. These staff sections will provide you with the necessary data to build the scenario; however, be certain the inputs from each are coordinated with each other.

You must also determine the concept of deployment for the wing as a component of the operations concept as to whether there will be three

squadrons at a single base of operations, two squadrons at a MOB and one at a FOB, three squadrons with one at the MOB and two at FOBs or deployment in elements of less than a squadron. Typically in wartime situations, you will find co-location of a squadron with other types of aircraft which offer varied possibilities of mutual support. A vital portion of the operations concept is identification of the types of missions to be flown, for this will impact the flying schedule. Examples of types of missions are: close air support, alert (air to air), interdiction, combat air patrol, tactical airlift, etc.

A scenario checklist is included as Appendix C. You will probably have to add or delete items to make it fit your problem. Where possible, provide a straw man to the individuals and organizations from whom you require information. Remember, it is always easier to add or delete items than to create an original document.

## V. MAINTENANCE CONCEPT

The maintenance concept will be obtained from the Director of Maintenance Engineering, a staff section of the Deputy Chief of Staff Logistics (LG) of the using command. The maintenance concept will vary with the operations concept; however, it is basically prescribed in AFM 66-1, Maintenance Management. Maintenance management is essentially a system of centralized management of specialist technicians with planning, scheduling, job control, materiel control, quality control, deficiency and production analysis at the Chief of Maintenance level. The Chief of Maintenance may be at the wing level or at the squadron level, depending upon the operational concept and the organizational structure. It is possible to have, for example, a wing of 72 UE fighters located at a single location with the wing chief of maintenance controlling the entire activity. A concept of two squadrons, 48 UE, at a main base and one squadron of 24 UE at a forward operating base would result in a split of maintenance assets with resulting limitations, i.e., a single squadron at the forward base would have one of two sets of avionics AGE for its support while the main base would have to support two squadrons with its set of avionics AGE. This concept could result in backlogs with ensuing lower aircraft availability. In either concept the wing chief of maintenance is responsible for supervision of the entire effort. An organizational chart of a wing maintenance organization is in Fig. 5-1.

A. Maintenance Organization Used in Simulation - A maintenance organization used in the LCOM simulation will be somewhat different than the concept discussed previously in that the staff functions of the Chief of Maintenance are not considered to be one of the work centers being modelled or assessed in the simulation. The reason for the decision not to include the Chief of Maintenance staff functions is that a manning factor has been established for his staff based upon the sum of the personnel assigned to the subordinate maintenance squadrons. An organizational chart depicting this situation is shown in Fig. 5-2.



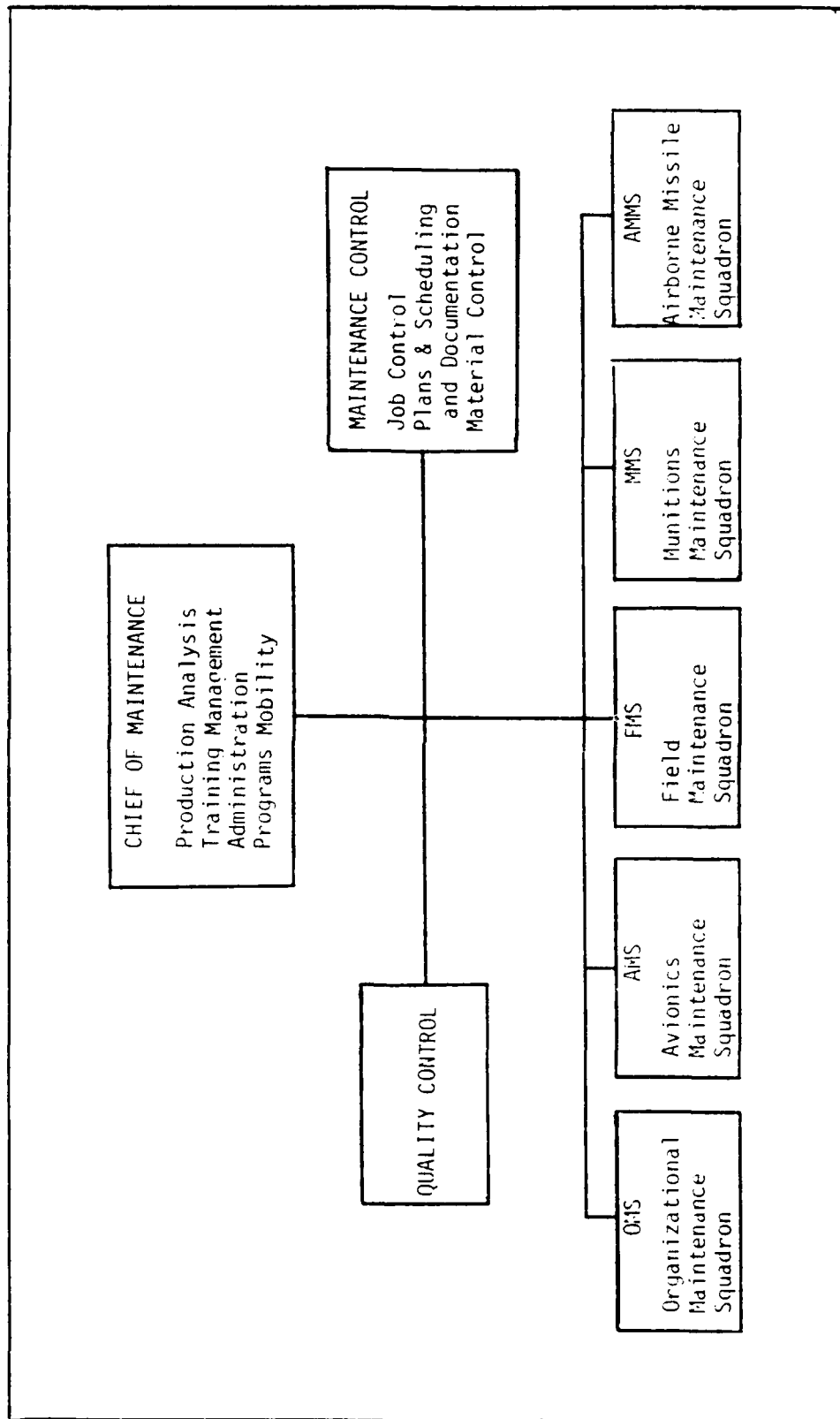


Figure 5-1. AFM 66-1 Chief of Maintenance Organization.

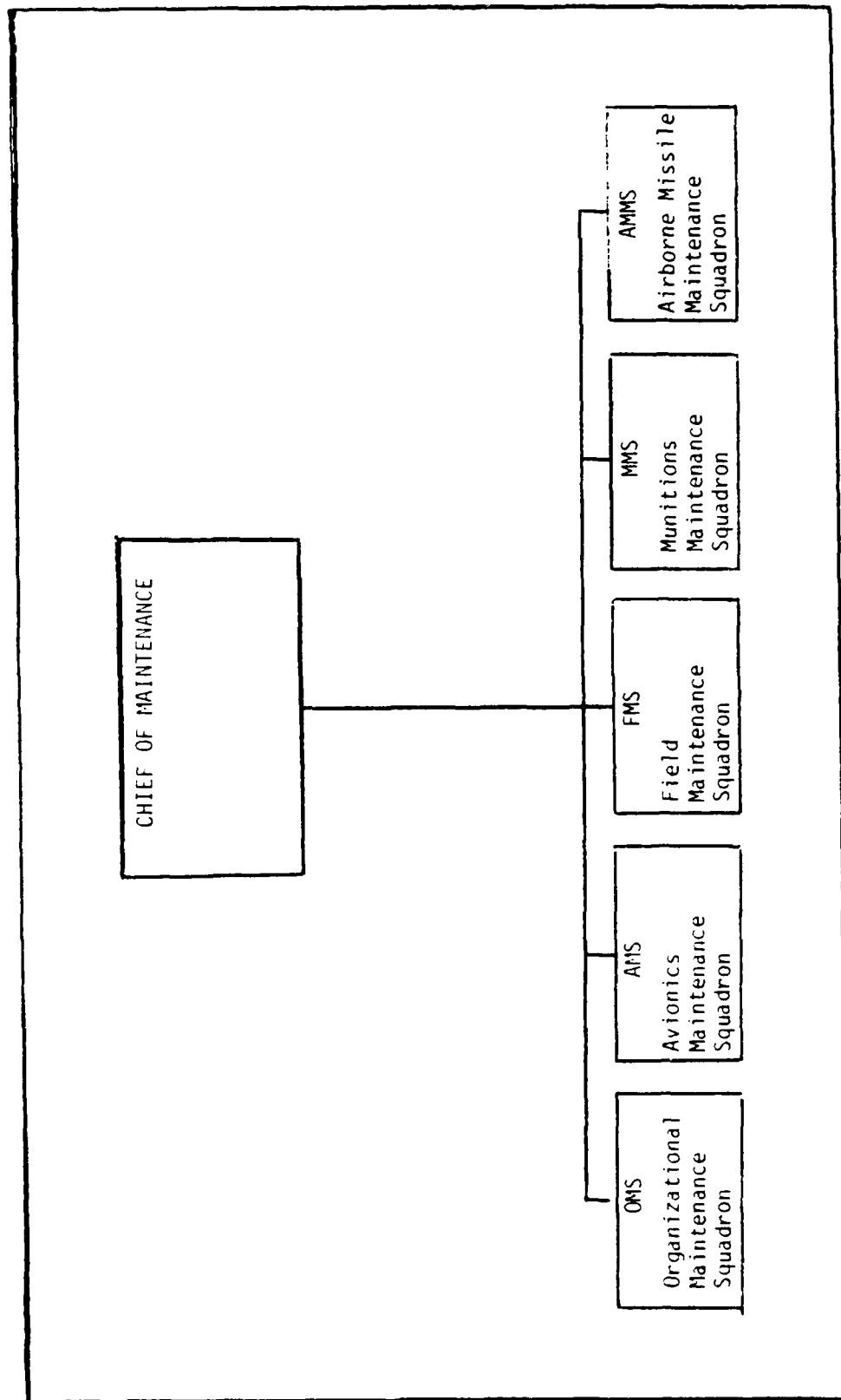


Figure 5-2. Chief of Maintenance Organization for Simulation.

8. Maintenance Policies - Maintenance policies, command or wing level, have a great impact on maintenance manning and capability to respond to the operational concept. Any policy is based upon some requirement, peculiar or general, and reflects on the maintenance concept accordingly. For example, a command may require a 431X1 aircraft mechanic to sit in the cockpit of a fighter while the aircraft APU is being operated and monitor the performance instruments for the APU. Or additional men can be consumed in requiring supplementary fireguards during refueling as a result of some previous aircraft fire in the command. Maintenance policies that could impact on maintenance manpower should be carefully recorded in the scenario assumptions. Frequently policies will impact or interface with each other. For example, in towing an aircraft to a revetment it may be required to have wing walkers, a tail walker, a man in the cockpit riding the brakes, a tug operator and a supervisor. Some of the same men would probably be used in a subsequent refueling operation. Additional items of maintenance policy which may be modeled are:

1. Preflight inspection tasks have precedence over other maintenance tasks.
2. Aircraft are preflighted individually for each sortie. Mass preflighting is not allowed.
3. No spare aircraft are preflighted.
4. Spares are preflighted, loaded and cocked.
5. Maintenance complex works two twelve-hour shifts six days per week.
6. Depot maintenance is not modeled.
7. Only organizational and depot maintenance levels are used.
8. Spares are prepositioned in WRSK at FOB with only remove and replace maintenance. Repairables are evacuated for depot repair.

Check out the peculiar policies with the command Director of Maintenance Engineering when obtaining information for the maintenance concept.

C. Maintenance Workload Factor - The maintenance workload factor for a flying organization is flying hours per month predicated on a flying hour allocation to the wing from the major air command or fragged sorties per day in wartime translated into flying hours. The allocation, flying hours or sorties, becomes the monthly flying schedule. Since equipment scheduled maintenance is based upon utilization rates expressed in operating hours, the Plans and Scheduling section in the Chief of Maintenance staff translates the flying hours or sorties into a monthly maintenance plan. This plan will include the tail numbers of the aircraft, their projected sorties-flying hours, preflight inspections, thru-flight-postflight inspections, phased inspections, time change items, special inspections, and washing if required. The Plans and Scheduling section in maintenance control will then relate the scheduled and estimated unscheduled requirements to work center capability to determine if they have a limiting work center. Done manually, this is a task of tedious and doubtful accuracy due to many unknown factors but is basically driven by unscheduled maintenance requirements. Thus simulation is an effective method of testing the maintenance requirements of the system.

D. Repair Level Concept - A very important element of the maintenance support concept is the repair cycle concept. The Optimum Repair Level Analysis (ORLA) determines the level of repair of a component which is expressed in the source, maintainability and recoverability codes. The repair cycle concept will demonstrate the relationship of maintenance and supply at base level. Stated simply, maintenance requisitions a recoverable part from base supply, authorized to be repaired at base level. Within a prescribed time BASO receives a serviceable, repairable, or condemned item in return. The repairable item is scheduled for repair through the Repairable Processing Center, a function of supply, and

returned to stock upon repair. Likewise, the serviceable item is also returned to stock upon determination of serviceability by bench check procedures. The primary objective of the repair cycle exercise in the LCOM simulation is to determine whether or not a true demand has been created on the supply system and to obtain an accurate measurement of the repair cycle time and the base level repair capability. (See Fig. 5.3 for schematic of a repair cycle.)

E. Parts Designation - Throughout an LCOM simulation, parts are designated by Work Unit Codes (WUC) listed in the applicable Air Force Work Unit Code Manual; i.e., T.O. 1F-105D-06. The WUC provides a unique, yet standardized method of designating individual parts that comprise a weapons system. Each part is assigned a five-digit alphanumeric code, where each digit supplies a level of definition. The first two digits define the class of equipment, the third digit defines the particular system, the fourth defines the component within the system, and the fifth, the part within the component. An example of the definitional breakdown of a WUC is shown below. Appendix H shows the classes of equipment for which maintenance may be provided within the simulation.

Breakdown of a Work Unit Code:

WUC: 71112  
71xxx: Radio Navigation Equipment  
71lxx: Radio Compass Equipment  
71llx: AN/ARN-6 Radio Compass  
71112: Control Panel, AN/ARN-6 Radio Compass

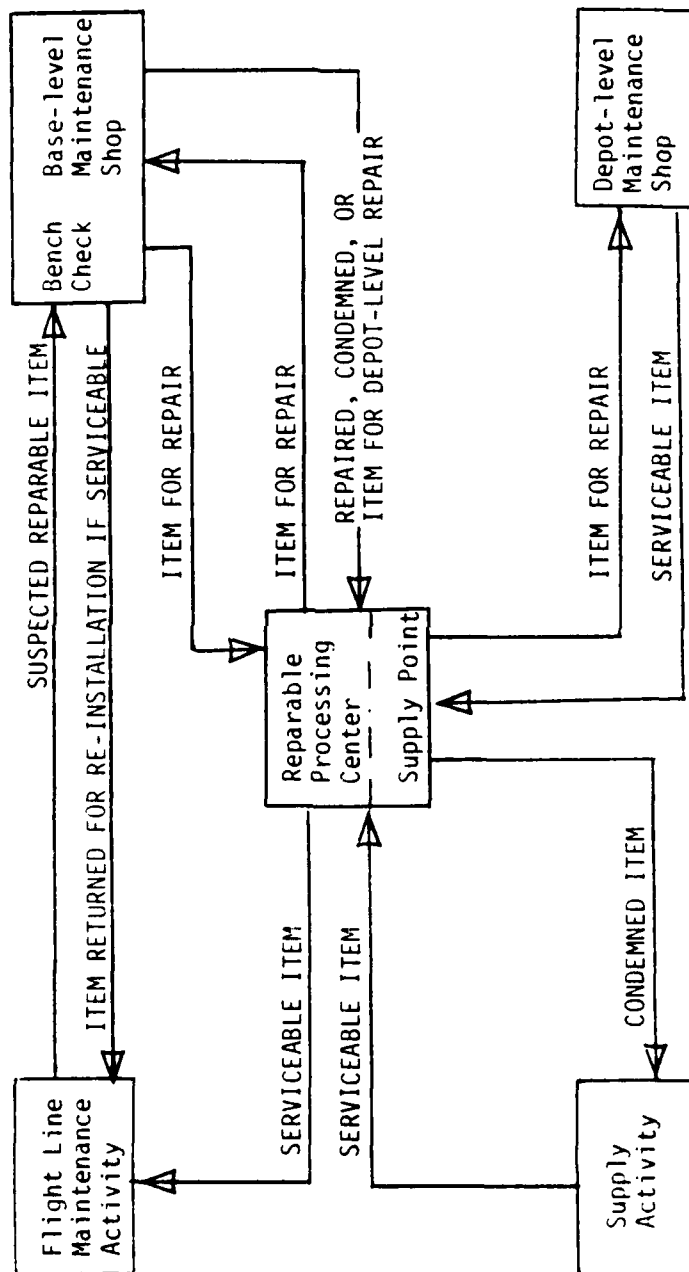


Figure 5-3. The Repair Cycle Process.

## VI. INPUT DATA REQUIREMENTS

A. Preparatory Data - Preparatory data for the LCOM simulation will be assembled through the research accomplished during the planning phase. As the analyst determines the information needed to conduct the study, he must begin to formulate ways of accumulating this information. There must be a means of collecting large amounts of raw data pertaining to the selected weapon system including maintenance data as well as flying hour data. These data should cover the same time frames and be as current as possible. While it would be quite premature to begin a discussion on the analysis of the data once it had been obtained, it is appropriate to direct the analyst's line of thought toward what types of data are available, and how they are produced.

1. Test Sensitive Data - There are several elements of test data which are sensitive in conducting an LCOM simulation on an emerging weapon system. Among these are:

- |  |                |
|--|----------------|
| a. Mean time between maintenance actions | e. Delay times |
| b. Mean time between failures            | f. Task time   |
| c. Mean time to repair                   | g. Crew size   |
| d. Manhours per flying hour              |                |

It may not be possible to get those data elements during test programs from the LSET chief and the analyst may have to resort to comparability analysis using AFM 66-1 Maintenance Data Collection System data from similar systems in the active inventory and stored in the data banks at AFLC. A substantial amount of effort is necessary to create a data base using the latter system in comparability analysis.

2. Weapon System Definition - Clear definition of the weapon system by MDS, its role, type of missions to be flown, UE of modeled unit, time frame of the simulation, planned sortie rates, attrition rates, non-nuclear ordnance consumables, and tank consumables is vital for an

accurate and reasonable simulation. The WMP series documents will be of substantial assistance in determining much of the definition. The scenario portion of the problem will provide other elements.

Discussion of the aircraft capabilities and configuration combinations with knowledgeable personnel will be of great assistance.

### 3. Operations Data.

a. When planning a simulation to determine maintenance manpower requirements, there could be a tendency to overemphasize the maintenance data to the detriment of the operations data. The analyst must keep in mind that the maintenance activity is supporting the operational requirement in both the real world operations or the simulation.

Either peacetime or full scale wartime operations may be modeled, but the end product must be used to fit the problem to be solved. The operations scenario may be highly varied because of the multiple roles the current aircraft can fulfill. The Operations Requirements Directorate in the using command will be able to provide the analyst with the details of the operations phase of the scenario. When meeting with the Operations Directorate the analyst should be prepared with a basic list of questions. Among suitable questions the following are offered for consideration:

- (1) Peacetime or wartime?
- (2) Number of aircraft based at same location?
- (3) What level of maintenance is available at the operating base?
- (4) Are there other types of aircraft sharing the same maintenance facilities?
- (5) If so, what are the priorities.
- (6) What is the desired sortie rate?
- (7) What is the average sortie length?
- (8) Is the following algorithm acceptable?

$\text{Sortie rate} \times \text{sortie length} \times \text{flying days/month} = \text{flying hours/month}$



(9) What are the types of missions?

(Interdiction, close air support, alert; air-to-air, combat air patrol)

Types of missions and requirements should be contained in a mission-load matrix. Consider different ordnance loads, tanks, camera film, gun ammunition, flares, and ECM pods as types of loads.

(10) Are loads permitted to be substituted? If so, what are the acceptable combinations?

(11) What proportion of the total sorties does each mission type represent?

(12) What is the average mission length, the desired number of aircraft and the priority for each mission type?

(13) How soon after scheduled takeoff will a mission be cancelled if the minimum number of aircraft are not ready?

(14) What is the policy for preparation of ground spare aircraft?

(15) What proportion of the aircraft scheduled to fly per day will be turned to fly a second time if possible?

(16) What is the proportion of day and night flying by mission type?

(17) What is a typical daily schedule (fragmentation order)? Is it basically similar for the entire period to be simulated?

(18) Are all available aircraft that are not scheduled to fly preflighted and available to load and fly if necessary?

(19) What is the variability on mission lengths?

(20) Do any aircraft stand alert? If so, how many and for how long? What mission types fly off alert, and what is the sortie generation rate for alert aircraft?

(21) How many weather days and weather cancellations are likely, and what mission types are affected?

(22) What is the period or schedule for major inspections (phase, corrosion, gun, etc.)?

#### 4. Maintenance Data Collection System Data

a. AFM 66-1 stipulates that a maintenance data collection system (MDCS) shall be used to enhance maintenance management. The MDCS begins at the technician level within a maintenance work center with the completion of the AFTO Form 349. This Form describes all maintenance actions taken by the maintenance technicians as they repair/replace items both on and off aircraft. This information is recorded noting the job control number, performing work center, MDS, owning work center, work unit code, serial number of end item, start time, stop time, crew size, operating time, action taken code, how malfunctioned code, when discovered code, activity I.D., etc. These data are keypunched and assembled, per AFM 66-267, at base level on tape, the ABD64A. This data system is an outstanding source of R&M data with which the analyst will be able to select specific bases and time frames for data selection; a sound basis for a LCOM data package.

b. K-97 Data - The K-97 historical data file is a series of computer tapes compiled by HQ AFLC at Wright Patterson AFB. This file is built from worldwide AFTO Form 349 maintenance action records filled out by maintenance technicians. The K-97 also describes all maintenance actions taken by the maintenance technicians as they repair/replace items both on and off the aircraft. This file may also provide the basis of the LCOM data base. As such, it would provide the historical maintenance data required for input to the Reliability Analysis and Comparability Analysis. The analyst should verify that the K-97 data are available for the weapon system under study and that they are the most recent data available. At least one year's data is recommended. K-97 data are more time consuming to use than the ABD64A data due to the extended sorting required because of its worldwide scope.

c. BLIS Report (Base Level Inquiring System Report) - The BLIS reports, produced at base level, are a source of local base repair actions (as compared with the worldwide K-97 data). However, its limitation is that the data only include the latest six months of AFTO Form 349 maintenance action records. BLIS reports are not an agglomerated listing, but are structured at the work center level, which lists, by work center, those maintenance tasks completed and reported via an AFTO Form 349. It also reflects the job control number work unit code, action taken code, malfunction code, crew size, units produced, and time to accomplish the particular task. These reports are especially useful in determining the AFSC requirements for performing the task at a given base. Information of this nature is vital when performing task time measurement at the base.

BLIS reports can be requested through the local MED which in turn coordinates the request with its local data automation office. Normally the request should specify only the particular work centers involved and specify only the most recent three months of data. Be sure that the BLIS report includes at least the work unit code, job control number, action taken, malfunction code, units completed, crew size, and task time (task duration). The ABD64A tape is the source from which a BLIS is extracted.

d. K-18 Data (RCS: 7302) - Since LCOM requires data in the form of maintenance repair/aircraft use (or more precisely, the probability of parts failing), a second form of data (the K-18) is required. These additional data will permit all weapon system maintenance covering a given period of time to be converted into maintenance actions per weapon system utilization. In other words, the K-18 data will enable the project team to determine the types of maintenance actions required per subsystem per sortie. The K-18 data provide this information by providing the number of sorties flown during the time period of the K-97 data.

The K-18 data are maintained for all using command weapon systems and are available through the Maintenance Requirements Section of the using command Directorate of Maintenance Engineering. The analyst should obtain these data as soon as the availability and time frames for the K-97 data have been established.

5. Supply Cost Data - By definition, supply cost is the unit cost of each aircraft system, subsystem or part. These data are needed by the LCOM model and are also required for use in the METRIC Program to establish spare parts levels. All parts which are used in a weapon system LCOM simulation are identified by their specific Work Unit Codes. Once all important parts are identified, a list of the parts by Work Unit Code, with accompanying nomenclature, should be compiled. If a MED assists in the study, they can obtain the exact cost data on each part by cross-referencing the Work Unit Code to its stock number via base supply. The LG of the using command is also an excellent source for this information. For emerging systems the LSET is also a good source.

6. Weather Data - Weather data is a very real requirement for the LCOM data package since adverse weather can significantly affect the overall operations of a given tactical unit flying a predetermined scenario. Thus weather data are needed for the home base as well as the target area and in the form required by the model. Weather information is available from the Environmental Technical Application Center (ETAC) in Washington, D. C.

7. Battle Damage Data - Since the purpose of an LCOM simulation is to determine aircraft maintenance manpower requirements for a tactical unit flying in a wartime environment, battle damage is a very real possibility. Such damage is obviously over and above that experienced

during normal peacetime operations. Thus some means must be available to the analyst to estimate this additional maintenance workload and incorporate it into the data package.

The War and Mobilization Plan, Vol VI (WMP-6), is the source for expected attrition rates for selected aircraft from which battle damage can be estimated. Also, the probability of RAM repair must be considered for aircraft returning with battle damage. The expected length of time the aircraft will be in RAM repair can cause an impact on maintenance workload. The Combat Data Information Center (CDIC) at Wright Patterson AFB can supply the needed combat battle damage information and the analyst should consult with CDIC as required. Battle damage assessment for newly emerging aircraft and for aircraft used against different threat environment than previously experienced, requires use of the Anti-Aircraft Artillery simulation (AAA).

3. Resources - All analysts would probably agree that identification of resources is important and would probably identify certain resources such as aircraft, manpower, parts and some facilities quite readily. Obviously assistance is needed to be certain that all of the needed resources are identified. To be certain that nothing is overlooked the operations and maintenance concepts, operations and maintenance policy and appropriate technical orders should be examined. Task analysis is also necessary for the determination of requirements. In changing a main landing gear tire the maintenance policy should be examined to determine whether the use of a hangar is required, a jack is definitely required and obviously a MLG tire and wheel. By the same token, a MJ-2 bomb loader is as necessary for the load crew loading bombs as a B-4 crew chief stand is necessary for a crew making an aileron change. It is recommended that a comprehensive task analysis be conducted for resource determination in conjunction with the creation of the network. Please note that the skill level identifier in the personnel AFSC is used in LCOM to denote special tasks such as end of

runway checks, i.e., 431R1. Cost of these resources may be obtained, in the case of test data, from the LSET, from the MED at the base for FOT&E, or from the using command LG; multiple sources exist, use them!

## VII. DATA BASE DEVELOPMENT

Having accomplished the research and data accumulation phase the analyst must consider the development of the data base. Organization of the LCOM data package can be best structured in the following manner:

### A. Operations Data

1. Mission type
2. Aircraft MDS and configuration
3. Sortie length and rate
4. Lead times
5. Cancel times
6. Mission Size
  - a. Minimum number of aircraft acceptable
  - b. Maximum number of aircraft that can be used on mission
  - c. Spare aircraft required
7. Mission Priority
8. Date of mission for simulation

9. Weather Effects Data - Weather effects have a strong bearing on operations schedules. The data may be obtained from ETAC and should be noted as yearly averages as opposed to seasonal averages. ASD has a computer model which includes resultant weather changes and weather holds in a simulated operations schedule.

10. Battle Damage - Battle damage data should be obtained from the Combat Data Information Center (CDIC) at Wright Patterson AFB, Ohio. If the data are not available, they may be produced from the AAA simulation which is used to provide attrition data and unscheduled maintenance data for air frame repair work centers.

B. Operations Data Application - The items listed in Operations Data are identified by the Operation Requirements Directorate of the using command for possessed systems. For emerging systems, coordination with Air Staff agencies is also necessary since the WMP documents are still being developed during this period. Those agencies are AFX00, AFPRM, AFLG, AFLGX, AFLGY. Do not fail to coordinate with the using command in both cases.

Having identified and obtained the data items from these agencies, the analyst should then code them on the LCOM Form 20, Sortie Generation Data, Form 13, Resource Definitions, Form 17, Mission Entry Points, and Form 19, Class Configuration Search Patterns. The analyst should then proceed in accordance with Chapter IX, User Procedures.

C. Maintenance Data. - Maintenance data are divided into three basic groups:

1. Direct Mission Support

a. Sortie generation, launch and recovery. These activities cover the series of actions necessary to generate a sortie such as preflight, munitions loading, engine start, pretaxi functional checks, end of runway checks (leak check, tire check, pull safety pins, bomb, tank and pod security, landing gear down lock pins removed). In recovery the end of runway checks are the same except for insertion of safety pins in pylons and recovering the drag chute, if used. Taxi guidance, parking, chocking, refueling and thru flight inspection are functions of recovery.

b. Aircraft Reconfiguration - A major task in direct mission support is aircraft reconfiguration. Reconfiguration constitutes tank, ECM pod, and multiple ejection rack changes or installation on a clean aircraft.



c. Common Items - Common to each of the functions described above are identification of task, crew size, probability of task being required such as guns reload, missiles down load or reload, refueling, etc.

2. Scheduled Maintenance - Scheduled maintenance is a function of use of sortie length. Its requirement is defined in the Dash Six Technical Order, i.e., 1F-105D-6, Scheduled Inspection Requirements. The scheduled requirements will be expressed as phased inspections. The number of inspections in a given time period constitute the scheduled inspection workload and are computed as:

$$\begin{aligned} \text{Sortie rate} \times \text{sortie length} \times \\ \text{flying days/month} &= \frac{\text{flying hours/month}}{\text{phased, periodic inspection or} \\ &\quad \text{isochronal interval.}} \\ &= \text{inspections required/month} \end{aligned}$$

These inspections may be scheduled through use of the Form 20 or through the Extended Form 11 using an F selection task.

The data elements for scheduled maintenance are the same as for unscheduled maintenance. Networks should be created as described in Chapter VIII using the inspection work cards.

### 3. Unscheduled Maintenance

a. Unscheduled maintenance is a function of operating failures or battle damage which occur on a random basis. Failure data, as previously called out in Chapter VI, may be obtained from test data, from contractor data, and from the MDCS. Data elements required to conduct unscheduled maintenance simulations are:

- (1) Work Unit Code
- (2) Mean time between maintenance action
- (3) Mean time between failures
- (4) Mean time to repair

- (5) Task time
- (6) Crew size
- (7) Delay times
- (8) Task probability

b. The following steps in developing this phase of the data base are suggested but are not limiting:

(1) Develop the Reliability Analysis - Extract the maintenance data from MISEDs collected on AFSC Forms 258 and 325 during test (IOT&E), the MEA, and or from the MDCS on the ABD64A Tape from base level during FOT&E. Depending upon the time the system is in the inventory it may be possible to obtain K-97 data. The data should be extracted by WUC and ATC. Through this analysis the frequency of maintenance actions by WUC may be determined and thus establish the items to be included within the network.

(2) Comparability Analysis

(a) It is a difficult task to determine the average rates of maintenance actions that will be performed on an aircraft that has been flying for several years. Although the equipment design is established, the kinds of missions to be flown, age of the equipment, quality control variability among different manufacturers of interchangeable components, climatic conditions, quality of troubleshooting aids, experience of pilots and maintenance personnel, level of spares on hand, extent of ground operation, command and local maintenance practices, and other unknown and transient factors impact how much work is done and reported on any given item in a specific time period. It is even more difficult to accurately predict "mature" maintenance rates for new aircraft that have not yet had extensive operational use.

One approach to comparability analysis is to use failure rates required by specifications or demonstrated in reliability tests. The improvement curves for reliability as a function of testing and correction are well

established. The trouble is that maintenance work occurs in the field 5 or 10 times more frequently than the "true" failures that are demonstrated on carefully built equipment under more idealistic test conditions, and the Maintenance K-factor cannot be predicted with consistency. Initial testing at Edwards AFB and during OT&E does not provide a large enough statistical data base by itself, and is complicated by design changes and deficiencies which are being corrected.

An alternate approach is to identify a comparable piece of equipment that is already in use for a similar purpose in a similar physical and operational environment, and then use field experience as a baseline for predicting maintenance frequency on the new equipment. This approach assumes that many of the unmeasurable factors will affect both items in a similar way, and that any design errors on the new equipment will be corrected during test.

The objective of comparability analysis is to establish the rate at which corrective maintenance will be done, analogous to the failure rate. Other maintainability factors (time, crew size, accessibility, AGE needed) will also be assessed, but are strictly secondary considerations in identifying comparable systems.

Level of Detail - Comparability identification must assure that there is access to a sufficient amount of field reported data on the comparable item. Air Force maintenance work is reported against work unit codes (WUC) so the LRU identification must be described in these terms. The WUC is a five-digit number. The first two digits represent an aircraft functional "system", such as propulsion, pneudraulics system, landing gear system, and fire control system. The third digit represents a further subsystem functional breakout, such as nose landing gear or fire control radar. The fourth and fifth digits represent line (LRU) or shop (SRU) replaceable units, such as hydraulic pumps, actuators, control panels, circuit cards, etc. There are also work unit code with a "9" in the

fifth position that represent all the lines, wiring, and miscellaneous parts that are not otherwise coded.

The first level of comparability that must be assessed is the subsystem. Every 3-digit level code on the new system should be paired with some 3-digit code(s) on existing systems. This is done because troubleshooting, functional check adjustments, "cannot duplicate" work, and many minor repair jobs are reported at this level. If only component comparabilities were used, this type of workload would be missed. In some cases there is absolutely nothing similar at 3-digit level, and the subsystem estimate must be built up from comparable LRUs. Extra care must then be taken to also include comparability for each type of subsystem level work mentioned above.

Within each subsystem, comparable items must also be identified for significant LRUs at 4- or 5-digit level. Each application is determined with respect to frequency of replacement cost if the item is carried in supply, use of shop AGE, and expected repair time. This level of information and configuration detail is not normally defined during the development phase until the aircraft has completed design reviews. Early analyses are generally limited to a 3-digit level of detail that is useful for preliminary manning predictions, but is not for estimating AGE or spares requirements.

Dimensions of Comparability - The most frequently asked questions when someone is asked to name a comparable subsystem is, "comparable in what way?" Unfortunately, that question does not have a definite answer. The critical variables for comparable maintenance frequency differ by subsystem and have not been adequately investigated. The analyst might not even know what are the most relevant ways to measure failures. Guns may fail in proportion of rounds fired, tires in proportion to landings, and starters in proportion to start cycles, but many kinds of gear seem to

fail on some obscure combination of cycles and duration of use. It is precisely because we don't know what to look at to establish comparability that we rely on the expert judgment of the engineers and maintenance specialists familiar with a given type of equipment. The objective of comparability analysis is to identify existing equipment that can be used as a baseline to predict frequency of maintenance on new equipment. The specialist must draw on years of practical experience and technical knowledge to know what are the most important considerations in making this determination.

This following checklist for making a comparability analysis is provided as a guide:

(a) Establish the measurement base:

Is maintenance frequency driven by the number of sorties, operating hours, flying hours, cycles, or what? If there is nothing better available, use sorties as the common base. How does the utilization of the planned equipment compare with utilization of similar gear on other aircraft?

(b) Equipment function:

What does it do, and what serves a similar purpose on other aircraft? How do key performance requirements compare?

(c) Design:

How complex is it, how big is it, at what rates and states does it operate? What is it made of and how does it work? Weight, cube?

(d) Quantity:

How many are there on the proposed aircraft, and how many on the comparable aircraft? (The number does not usually affect selection of a comparable item, but must be known to correctly interpret maintenance data from the field).

(e) Operating environment:

Under what conditions does the subsystem or LRU operate when installed? In what ways is it used (e.g., in the air, on the ground, in a pressurized cabin, subject to gun vibration, contamination, corrosion)?

(f) Maintenance environment:

What command uses it; what is the concept of maintenance? How much preventative maintenance and/or inspection is done? (Maintenance rates on the same equipment vary by command).

Establishing Adjustment Factors - There is seldom a perfect match between two pieces of equipment for all the characteristics that could impact frequency of corrective maintenance. The expert, who identifies a comparable item must also develop some arithmetic factors which can be applied to the field data to adjust for differences between the new and the comparable equipment. The factor on maintenance rate should be expressed as a fractional decimal. A factor less than one means the new equipment will require corrective maintenance less often, while factors greater than one more often, than the comparable item.

For example, suppose engine starts was identified as the measurement base. If the new starter is expected to be twice as good in the field as the starter identified as comparable, a .5 factor would be indicated. The maintenance model for the new aircraft would show half as many starter maintenance actions per start as the comparable starter had experienced.

Once the comparable item and maintenance frequency factor are determined, then any major differences in maintenance methods, task times, and crew sizes may also be assessed. These differences may be expressed as a numeric factor and/or described in preceding narrative, but should be identified as access, troubleshoot, replacement, checkout or shop checkout and

repair tasks. Any differences in required AGE or in scheduled inspection/ service requirements should also be annotated.

#### Exceptions

A few subsystems will be so different, or incorporate such new state of the art technology, that no comparable equipment can be identified. In these cases the estimated maintenance frequency must be built up or factored from reliability demonstration data, with careful attention to all the considerations listed above.

Engines are also an exception in that lower indenture comparability is not useful. The engine operates as an entity, and comparability must be assessed for a whole engine. If that is not possible, the task estimates must be built up, starting with an estimate of the premature removal rate. However, the engine accessories and engine mounted equipment are conveniently handled by comparability procedures.

1. Equipment and WUC
2. Number installed
3. Comparable Equipment, A/C, and WUC
4. Number Installed
5. Measurement Base
6. Duty Cycle per Sortie,  
if other than sortie base
7. Reliability Factor
8. Rationale
9. Maintainability factors and rationale:
10. Other significant differences (AGE, scheduled maintenance, etc.)

COMPARABILITY STUDY FORMAT



## SAMPLE CONSIDERATIONS FROM PREVIOUS STUDIES

AIRFRAME:	Empty weight, square foot area, stressed or nonstressed construction, materials (e.g., use of composites) Number and type of doors access panels, and windows, relative numbers and type of fasteners, expected "G" loading, speed and cycling under various mission profiles.
COCKPIT:	Windshield/canopy material and area, type of ejection/escape system.
LANDING GEAR:	Landing weight and speed, number, ply and size of tires, wheel loading, brake material, idle thrust and taxi speed, methods of retraction, steering, control.
FLIGHT CONTROLS:	How powered, extent of automatic and electronic control, size and kinds of control surfaces, a/c maximum speed.
PROPULSION:	Type of engine, by pass ratio, number and kind of stages, size and maximum thrust, cycling under various mission profiles, materials, and operating temperatures, on-condition instrumentation, type of starting, fuel specifics.
AIR CONDITIONING/ HEATING:	Method of heating/cooling, type of heat exchange, size of cabin, crew, amount of avionics to be cooled, operation on the ground, manufacturer.
ELECTRICAL AND LIGHTING:	CSD manufacture, how generator is driven, kVA, voltage, phase/frequency, generator RPM, capacity of transformers/inverters, type of battery, extent and type of wiring.

PNEUDRAULICS:	Number and capacity of pumps, how the pumps are driven, system redundancy, operating pressures, type of tubing, fittings, system pressure.
FUEL SYSTEM:	Number and size of integral and bladder tanks, tank sealant, number, type, and location of pumps, valves and probes, pump capacities and power source, system feed mechanism and operating pressure, fueling points.
INSTRUMENTS:	Comparison of individual instruments by function, type sensor, type of readout, power requirements.
AVIONICS:	Function, parts count, operating power, complexity, interconnects and multiplexing, cooling and pressurization, vibration frequency, and type of rotating electro-mechanical components, solid state vs. tube, number of connectors and operator controls, number and type of signals displayed.

NOTE: Techniques exist for assessment of avionics specification/demonstration reliability by buildup techniques and/or statistical regression. These techniques utilize parts counts, complexity factors, and/or component reliability data. They may be useful in establishing the adjustment factor due to design differences between new and comparable equipment.

EXAMPLE OF SUBSYSTEM LEVEL COMPARABILITY WRITE-UP FOR A-10

1. Hydraulic Systems PC1 and PC2 2. (1)  
WUC 45A00  
WUC 45F00 (Indicating Systems)

3. A7D Hydraulic Systems PC1 and PC2 4. (1)

5. Per Sortie Base 6. N/A

7. Reliability Factor: .75

8. Rationale:

The A-10 hydraulic system is similar to the A-7 in that both aircraft are subsonic and use the same size and speed hydraulic pump. The A-10 however is a dual engine aircraft giving the hydraulic system an inherent dual source of power which provides for greater reliability. The A-7 has been plagued with hydraulic overheat problems due to high pump heat rejection and lack of proper system cooling. Both of these problems have been addressed in the A-10 which should result in increased reliability. The A-7 uses permanent brazed hydraulic fittings internal to the wing fuel tank. The A-10 will employ permanent swaged fittings where possible throughout the aircraft and permanent ends on detachable fittings where a detachable fitting is required. This will give the reliability aircraft and represents a system that is lower in initial cost and easier and simpler to maintain. Use of modular packaging to a great extent also increased maintenance and reliability of the A-10 over the A-7. Based on the above, the A-10 is considered to have a .75 reliability factor over the A-7.

9. Maintainability:

The A-10 has good maintenance access in service areas and in troughs along the fuselage. This would rate a .75 on A/C maintenance factor in comparison to the A-7. However, due to inclusion of rigid foam in the trough area, the figure should be revised upward to at least equal (1) of the A-7. Due to design of modular components and plug-in packages, the off-aircraft maintenance should be .9 that of the A-7.

(3) Develop Mapping Function - Develop a listing of Work Unit Codes that allows for the combination of individual codes into a specific system.

(4) Obtain Unit Cost Data - Cost data should be collected for items specifically identified in the Reliability Analysis. These data can be obtained in the field during test from the LSET and/or collected from the command LG through the project liaison officer.

(5) Develop Unscheduled Maintenance Networks - Based upon the data obtained from the Reliability Analysis, develop networks that will depict the flow of maintenance actions in the proper repair sequence and probabilities that will govern the occurrence of different maintenance actions. The MEA could be of substantial assistance during this effort for an LCOM simulation during IOT&E. Use Chapter VIII as a guide.

(6) Develop Engine Repair Networks - Using the K-18 data in the same manner as in the unscheduled maintenance network computations, develop the on and off equipment maintenance networks for the engine repair. These networks will consist of a greater quantity of shop work than any other single work center. K-18 work data and task buildup, using experienced engine technicians, will probably be more accurate than using K-97 data.

D. Data Base Listing - A standardized data base listing is a substantial assistance. Standard codings have been recommended herein and are discussed in detail in AFHRL-TR-74-98(II). The following example of a data base listing has been used effectively in a simulation and analysis of a current weapon system.

## DATA BASE LISTING

1. The maintenance tasks are listed in the following format:

a. HEADER ENTRIES:

- LRU name or left blank
- H (Code indicating header card)
- Nomenclature of the network segment that follows the header card.

b. MAINTENANCE TASK ENTRIES:

- Beginning Node Name
- Action Code and Task Name
- Ending Node Name
- LCOM Selection Mode
- Probability or Failure Clock Value
- Network Name
- Maintenance Type and Task Priority
- Task Time (in tenths of hours)
- Time Variability and Distribution Type
- Quantities and Types of Resources (Men, AGE, etc.)

2. Coding used includes the following conventions:

a. ACTION CODES:

- F = Failure Clock
- T = Troubleshoot on-aircraft
- C = Work to Facilitate Maintenance (Access, Preparation, etc.)
- A = Get and Hookup AGE
- R = Remove/Replace LRU
- M = Repair on-aircraft
- V = Verify Systems Work
- W = Check and Repair In-Shop

- K = Check OK in Shop
- N = Check and NRTS/Condemn
- J = Aircraft Handling
- B = Loading/Downloading
- G = Fueling
- H = Flightline Inspection/Service
- P = Phase Inspection
- C = Call Section (Reference to a sub-network)
- Q = Draw LRU from Supply
- D = Decrement a Failure Clock
- Z = Sortie and Other Non-Maintenance Tasks

b. Task names for unscheduled maintenance indicate the work unit code of equipment being worked on. Task names for general aircraft servicing and support tasks are mnemonic abbreviations of the task description. For example, the task of reloading the gun is named LDGUN, and the task of servicing liquid oxygen is named LOXSV.

c. LCOM SELECTION MODES:

- A = Non-Mutually Exclusive Probability
- C = Call Section Reference to a Sub-Network
- D = Task Done in Indicated Order
- E = Mutually Exclusive Probability
- F = Task Done if Indicated Failure Occurs
- G = Relative Probability, Non Mutually Exclusive
- H = Task Not Done if Indicated Failure Occurs
- I = Task Done Only if Cannibalization is Required
- S = Fly Sortie
- X = Task Done when Failure Occurs in Subsequent Tasks

d. Task resource names are the Air Force Specialty codes of maintenance personnel, or mnemonic abbreviations for AGE equipment. For example, LXCART indicates a liquid oxygen Service cart, and D60 indicates an M32-60 Ground Power Unit. The fourth (skill level) digit of the Air Force Specialty code is replaced by an X, except in cases where a further breakout or shredout is necessary. These include:

- 326A1 - Automatic Test Stations
- 326A2 - Fire Control/Inertial Flightline
- 326B1 - Manual Test Stations
- 326B2 - Flight Control/Instrument Flightline
- 326C2 - Comm/Nav/ECM Flightline
- 462Y0 - Weapons Release
- 462Z0 - Munitions Load Team
- 431A1 - Alert Pad Maintenance Crew
- 462A0 - Alert Pad Munitions Crew
- 431R1 - End of Runway Maintenance Crew
- 462R0 - End of Runway Munitions Crew
- 362R2 - End of Runway ECM Crew
- 431P1 - Phase Inspection Crew
- 431C1 - Aero Repair Shop (creash cerw).
- 431Y1 - Wheel/Tire Shop
- 432T0 - Engine Test Stand Crew

3. The connection of unscheduled maintenance to call sections is done automatically by the processing program and is not specifically shown in the data base.

## VIII. NETWORK CONSTRUCTION

A. Purpose - The purpose of creating networks is to graphically portray the flow diagrams of the manifold tasks of flying the sortie, and maintenance and supply support which includes preflight inspection, service, weapons loading, thru-flight inspection, postflight inspection, unscheduled, scheduled (phased) maintenance and supply demand actions. Task times, their variance, distribution, crew size, AFSC of crew member, and AGE necessary to complete the task are designated in the tasks within the networks.

B. Prerequisites - The following items are considered as prerequisites in developing networks for LCOM:

1. Knowledge of LCOM Procedures
2. Knowledge of networking techniques
3. Knowledge of the weapon system and its subsystems
4. Competence in the use of the WUC Manual
5. Knowledge of how the MDCS is operated and how it is used in collecting and recording the maintainability and reliability parameters for the system being modeled, reference T.O. 00-20-2.

C. Concept of Networks

1. The LCOM networks are created to logically sequence and prioritize the actions necessary to fly the sortie and support the weapon system. A network identifies the tasks that must be accomplished prior to, during, and after the mission and identifies the time and resources required for each task. Nodes or connecting points specify the task processing sequence to the computer program. Every task, however, does not have to be done in the same sequence. Doing a task can be made contingent on a probability or on the occurrence of some other simulated event.



2. Network structure is tailored to the mission requirement and is quite simple in concept. Any network begins with a node identified by a number for the computer program to identify the task and proceeds with the sequence of events, step by step, until the final desired event is reached. Each step in the network is separated by a node and some segments which can modify a decrement clock value to indicate the malfunctions and delays that take place in the real world.

a. Network Sections - Network sections are used to simplify the drawing of the network and are identified as called or reconfiguration nodes. These subnetworks are drawn separately from the main network flow and are so identified with their respective node names. A call task is a dummy representation of the tasks within a section of network. All applicable tasks within the network section must be completed before the call task can be completed, or any succeeding task started. No parallel tasks can precede a sortie unless they are contained within a call section. Call sections are fully identified the first time they appear and thereafter merely referred to. The user may need to specify that a series of actions be repeated in a network such as refueling or rearming. To simplify the networking he simply refers to a called node to repeat the tasks.

b. Coding Networks - Each segment of the network is coded to reflect the task being performed, the selection mode (Appendix J), and a decrement if applicable.

#### D. Types of Networks

Networks are created for the following situations:

1. Operations networks.
2. Unscheduled maintenance as a result of on-equipment failures.
3. Scheduled maintenance as a result of sortie length and activity, a phase inspection, a tire change, or a time change item.

4. Shop maintenance which may be a result of either unscheduled maintenance or the result of the look phase of the scheduled maintenance inspection phase package. (See Fig. 8-1).

Logic networks may be particularly difficult to develop in the engine shop area due to so much of the unscheduled maintenance being reported in such a generalized manner that the MDCS probabilities may not be meaningful.

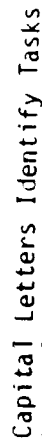
Variations in the methods of reporting the frequency of engine removals will probably cause confusion by the use of the MDCS for engine networking. It is recommended that the base level K-18 Report be used to determine the mean engine removal rate.

The best source of guidance for determining the sequence, frequency of actions, manning, AGE required for an engine troubleshooting, repair, replacement, test cell, trim pad, FCF, are personnel operating an engine shop for comparable engines. A sample engine network is shown in Fig. 8-2.

CAUTION: NETWORK ONLY THE SIGNIFICANT ITEMS,  
AGGREGATE "ALL OTHERS" WHEN DEALING  
IN LOW FAILURE RATES. THE SUM OF  
MANPOWER IS THEN SIGNIFICANT.

- a. Example of Networks for Fighter-Bomber Aircraft -  
Interdiction Mission; First Flight of the Day to Turn

This example is a straightforward depiction of the series of events that constitute the preparation for a sortie, Redball Maintenance, launching and flight, the malfunctions that occur, recovery, LOX servicing, refueling and rearming. (See Fig. 8-3).



Lower Case Letters Indicate Selection Mode:

**f = Task is only done when clock indicates failure**

e = Mutually exclusive probability, only one path selects.

g = Independent probability, one or more paths selected

`d = Task` is always done.

\* = This and any subsequent work is on the LRU, and does not necessarily detain the aircraft.

Figure 8-1. Subsystem Corrective Maintenance Network Basic Logic.



1A10	1 X001	95	05	10	
				00010	INT FIRST TURN
INT100	CALPRE	INT101	C	00010	31
INT101	B2GB10	INT106	D	00010	31 10 10L 446270 1MJI 1060
INT106	HENGST	INT108	D	00010	31 4 29L 2431X1
INT108	DCRMT1	INT110	D	00010	31
INT110	CALEGD	INT112	C	00010	31
INT112	CALJKD	INT114	C	00010	31
INT114	CALLQM	INT115	C	00010	31
INT115	CALLS2	INT116	C	00010	31
INT116	JTAXIO	INT118	D	00010	31 2 10L
INT118	HEORGO	INT120	D	00010	31 1 10L 2431X1 4462R0 2426R2
INT120	200000	INT124	S	00010	31
INT124	DCRMT2	INT126	D	00010	31
INT126	DCRMT7	INT130	D	00010	31
INT130	HEORIN	INT132	D	00010	31 1 29L 2462R0
INT132	JTAXIN	INT136	D	00010	31 2 10L
INT136	JTOWIN	INT140	D	00010	31 2 10L 6431X1 1TUG
INT140	HTHRUE		D	00010	31
INT140	HTHRUE		D	00010	31
INT142	CALJK1	INT144	C	00010	31
INT144	CALLSV	INT145	C	00010	31
INT145	GASF16	INT154	D	00010	31
INT154	CALECM		C	00010	31

Figure 8-3. Interdiction Mission, First Flight of the Day to Turn - Int First Turn.



		H	00010	INT TURN-LAST
INT200	B2G310	INT206 D	00010 31	
INT206	BENGST	INT208 D	00010 31	
INT208	DCRMT1	INT210 D	00010 31	
INT210	CALEGD	INT212 C	00010 31	
INT212	CALJKD	INT214 C	00010 31	
INT214	CALLQM	INT215 C	00010 31	
INT215	CALLS2	INT216 C	00010 31	
INT216	JTAXIO	INT218 D	00010 31	
INT218	HEORGO	INT220 D	00010 31	
INT220	200000	INT224 S	00010 31	
INT224	DCRMT2	INT226 D	00010 31	
INT226	DCRMT4	INT227 D	00010 31	
INT227	DCRMT7	INT230 D	00010 31	
INT230	HEORIN	INT232 D	00010 31	
INT232	HTAXIN	INT236 D	00010 31	
INT236	JTOWIN	INT240 D	00010 31	
INT240	CALPST	C	00010 31	
INT240	CALEG1	INT242 C	00010 31	
INT242	CALJK1	INT244 C	00010 31	
INT244	CALLSV	INT245 C	00010 31	
INT245	GASF16	INT254 D	00010 31	
INT254	CALECM	C	00010 31	

Figure 8-3 (Con't). Int Turn - Last.





CALLSV	SWAITG	ISV001	D	00010	31	SERVICE WHILE WAITING FOR REFUELLING
CALLSV	CALLS1	ISV001	C	00010	31	
CALLSV	J00000	ISV002	A	32	00010	31
ISV002	CALFUL	C		00010	31	
CALLSV	CLGUN3	C		00010	31	
CALLSV	DCRMG3	ISV003	A	27	00010	31
ISV003	CALGPU	ISV004	C		00010	31
ISV004	B2AIM9	D		00010	31	6 10L 446270 1D60
ISV004	BMSAGE	D		00010	31	

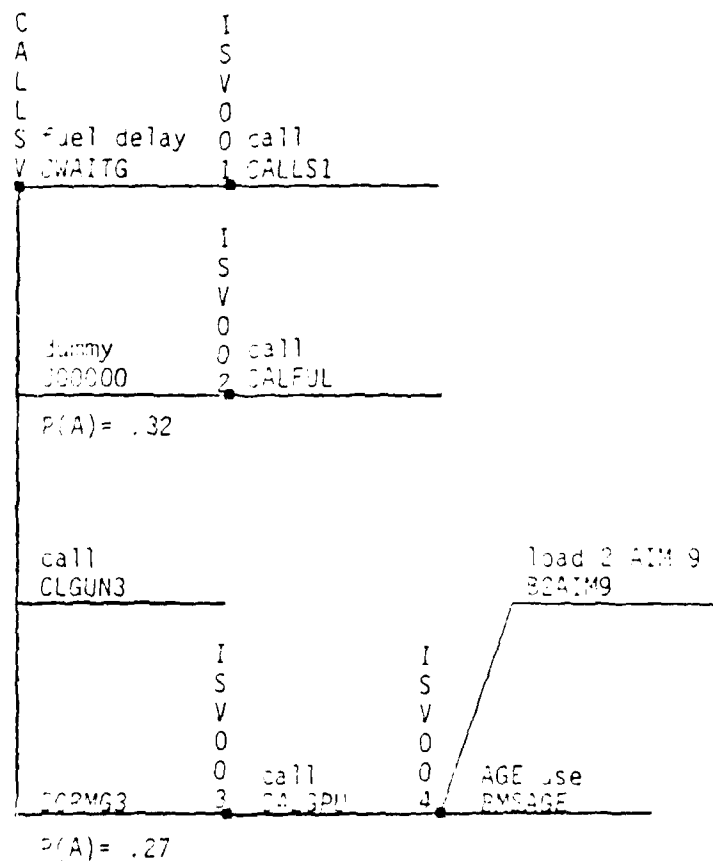


Figure 8-3 (Con't). Service While Waiting For Refueling.  
8-10

		H		00010		<u>CHANGE MALFUNCT ECM POD</u>
CALECM	DCRMG2	J0030	A	10	00010	31
J0030	CALGPU	J0032	C		00010	31
J0032	BECMLD		D		00010	31
J0032	BECMAG		D		00010	31
					10	10L 3326C2 1MJ1
					5	10L 1D60

C				
A		J		J
L		0		0
E		0		0
C	AGE	3	call	3
M	DCRMG2	0	CALGPU	2
				load ECM pod
				BECMLD

use AGE  
BECMAG

		H		00010		<u>HANG 2 EXTERNAL TANKS</u>
CALFUL	BHANGT	J0040	D	00010	31	10 29L 3431X1
J0040	DCRMG2	J0042	D	00010	31	
J0042	CALGPU	J0044	C	00010	31	
J0044	HJETCK	J0046	D	00010	31	2 29L 146220 1D60
J0046	GASCKT		D	00010	31	5 29L 2431X1
			H	00010		BUILD UP OF TANKS WARTIME
CALFUL	BBLDTK		D	00010	31	30 29L 2424X0

C					
A		J		J	J
L		0		0	0
F		0		0	0
U	hang tank	4	AGE	4	call
L	BHANGT	0	DCRMG2	2	CALGPU
					4
					jet. check
					HJETCK

build tank  
BBLDTK

Figure 8-3 (Con't).

		H	00010	MAIN NETWORK FOR PREFLIGHT DUMMY SORTIE	
		H	00010		
J00000	CALPRE	J00002	C	00010	31
J00002	Z000000		S	00010	11
		H	00010	PREFLIGHT	
CALPRE	DCRMG3	J00004	D	00010	31
J00004	CALGPU	J00006	C	00010	31
J00006	HPFAGE		D	00010	31
J00006	HPRFLT		D	00010	31
J00006	HCODES		D	00010	31
CALPRE	HLOXSV	A	33	00010	31

5 29L 1D60  
15 29L 1431X1  
7 29L 2326C2  
3 29L 2431X1

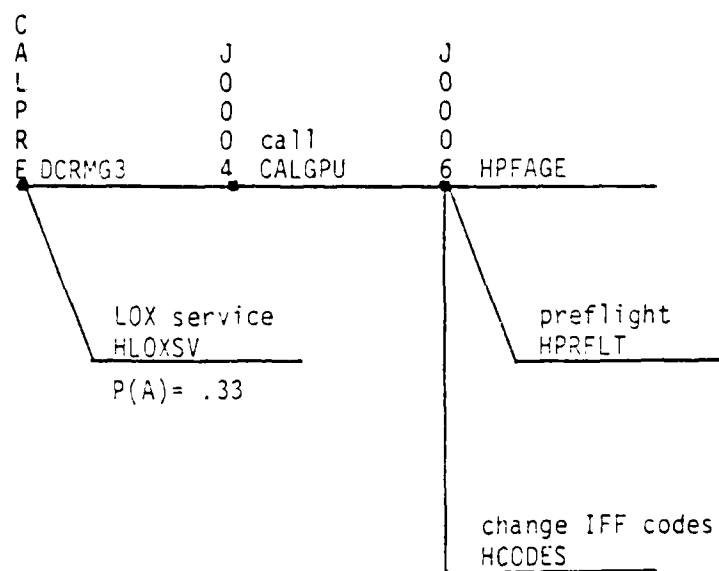


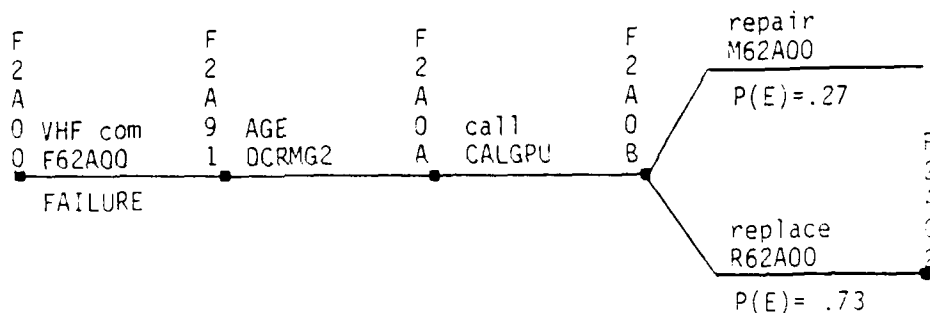
Figure 8-3 (Con't). Main Network For Preflight Dummy Sortie.

CLGUN3 BLDGUN H 00010 GUN RELOAD (INT)  
A 20 00010 31 4 10L 3462X0

C  
L  
G  
U  
N  
3 BLDGUN

$P(A) = .25$

			H	62A00	UNSCHEDULED NETWORK FOR VHF COMM
F2A00	F62A00	F2A01	F	46 62A00 21	
F2A01	DCRMG2	F2A0A	D	62A00 21	
F2A0A	CALGPU	F2A0B	C	62A00 21	
F2A0B	R62A00	F2A02	E	73 62A00 21	15 29L 2326C2
F2A0B	M62A00		E	27 62A00 21	10 29L 2326C2



			H	D6000	AGE DISPATCH
CALGPU	AD6000	AD6004	D	5 29L 1421A3 1D60	
AD6004	FD6000	AD6005	F	9 D6000 21	
AD6005	MD6000		E	60 D6000 21	
AD6005	AD6000		E	40 D6000 21	

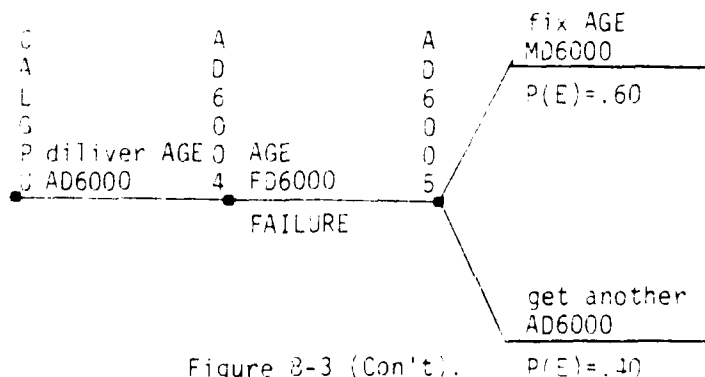


Figure B-3 (Con't).

			H	62L00			
			H	62L00			
F2L00	F62L00	F2L01	F	46	62L00	21	
F2L01	RF2AA0	IF2AA0	D		62L00	21	3 29L 2326C2

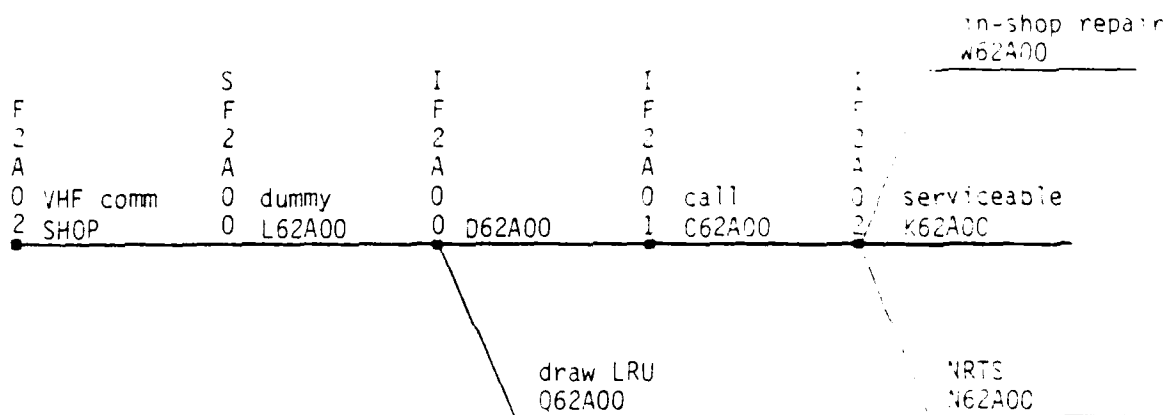
			I
F	F		F
2	2		2
L	L		A
0 VHF comm	0 replace		0
0 F62L00	1 RF2AA0		0

---

FAILURE

Figure 8-3 (Con't). Launch Network Maintenance VHF Comm.

F2A00	SHOP	SF2A00	D	62A00	23			
SF2A00	L62A00	IF2A00	D	62A00	23			
	L62A00		H	62A00		<b>VHF COMM SYS</b>		
IF2A00	Q62A00		I	62A00	21	20	29L	2326C2
IF2A00	D62A00	IF2A01	D	62A00*	23			
IF2A01	C62A00	IF2A02	C	62A00	23			
IF2A02	W62A00		E	75	62A00	23	39	29L 1326A1 IPTSM IPTSM
IF2A02	K62A00		E	17	62A00	23	18	29L 1326A1 IPTSM IPTSM
IF2A02	N62A00		E	00	62A00	23	30	29L 1326A1 IPRSM IPTSM



		H	S4700	<b>LOX 60 DAY LEAK CHK</b>	
S4700	FS4700	S4701	F		
S4700	VS4700		D		
			00	S4700	
				S4700	
				5	29L 1422X1

S	S
4	4
7	7
0	0
LOX 60 day	inspection
FS4700	VS4700
0	1

leak check

Figure 3-3 (Cont).

			H	41A00	ENVIRONMENTAL CONTROL SYS			
D1A00	F41A00	D1A0C	F	63	41A00			
D1A0C	DCRMG7	D1A01	D		41A0J	21		
D1A01	A41A00	D1A02	E	92	41A0J	21	02 29L	1431X1 1B4
D1A01	X41A00	D1A0B	E	08	41A0J	21	05 29L	1431X1
D1A0B	X41A01	D1A02	D		41A0J	21	35 29L	3462X0 1MJ1 1MJ4
D1A02	F41A00	D1A13	D		41A0J	21	10 29L	2422X1 1B4
D1A13	F41A01	D1A03	D		41A0J	21	5 29L	2422X1 1B4
D1A03	R41A0J	D1A04	E	60	41A0J	21	25 29L	2422X1 1B4
D1A03	M41A00	D1A05	E	40	41A0J	21	11 29L	2422X1 1B4
D1A04	V41A00	D1A14	D		41A0J	21	03 29L	2422X1 1B4 1431X1
D1A14	V41A02		D		41A0J	21	08 29L	2422X1 1B4
D1A05	V41A01	D1A15	D		41A0J	21	03 29L	2422X1 1B4 1431X1
D1A15	V41A03				41A0J	21	08 29L	2422X1 1B4
D1A04	SHOP	SD1A00	D		41A0J	21		

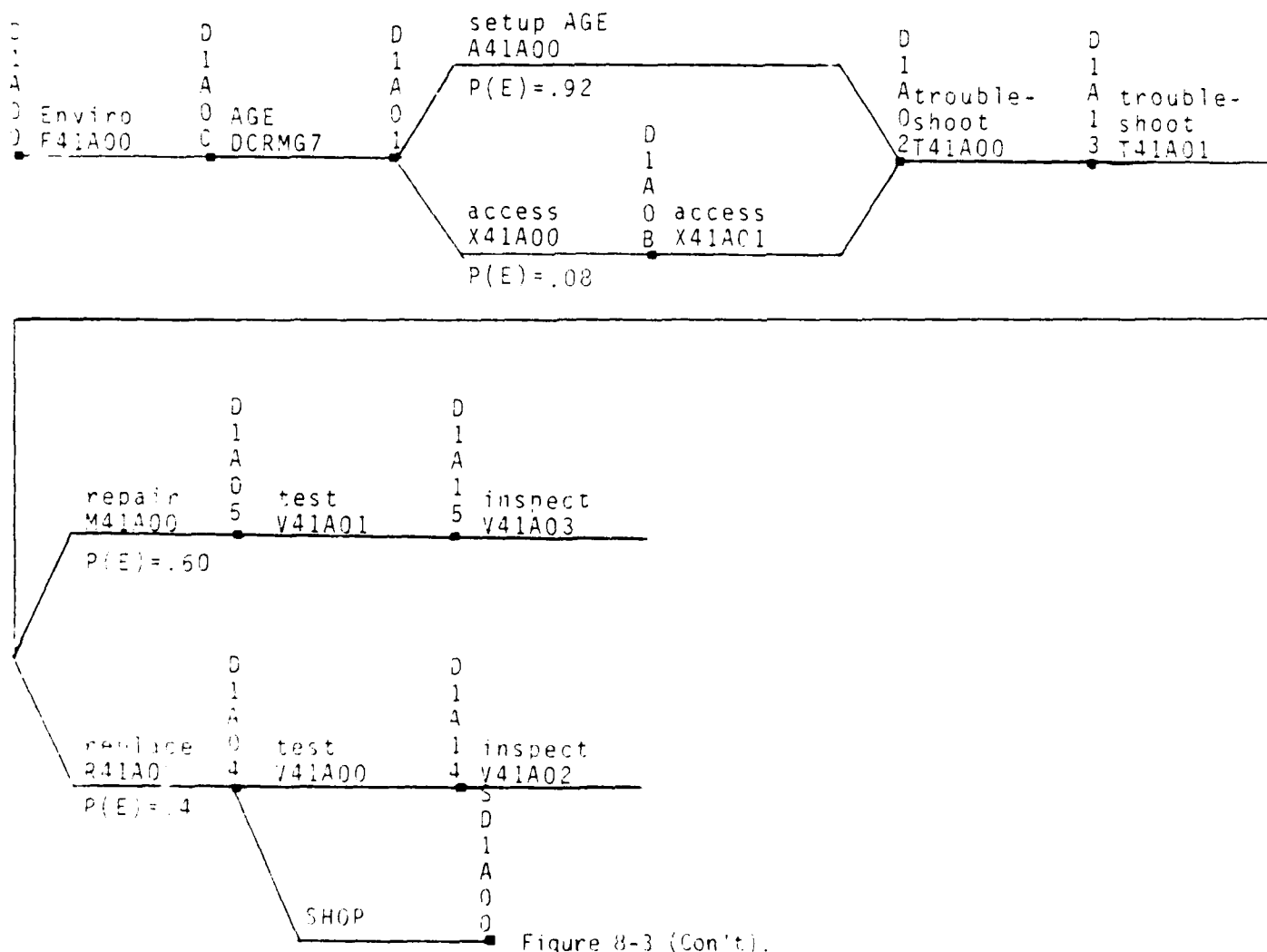
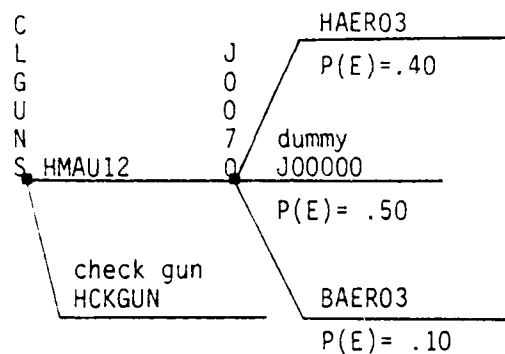


Figure 8-3 (Con't).

				GUN AND MUNITIONS END OF DAY INSP			
CLGUNS	HMAU12	J0070	D	00010	31	5	29L 4462Y0
CLGUNS	HCKGUN		A	54	00010	31	4 29L 2462Y0
	J0070	HAER03	E	40	00010	31	2 29L 4462Y0
	J0070	BAER03	E	10	00010	31	4 29 4462Y0
	J0070	J00000	E	50	00010	31	



				POSTFLIGHT INSPECTION			
CALPST	HTHRUF		E	86	00010	31	6 29L 1431X1
CALPST	DCRMG3	J0060	E	14	00010	31	
	J0060	CALGPU	C		00010	31	
	J0062	HPEAGE	D		00010	31	
	J0060	HPOSTF	D		00010	31	30 29L 1431X1

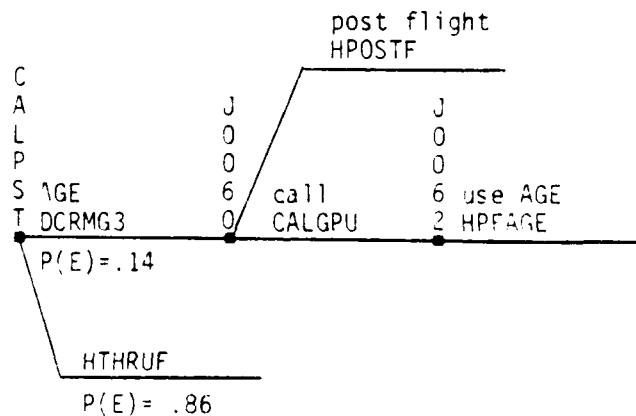


Figure 8-3 (Con't).



## IX. USER PROCEDURES

To simulate the flying of the sortie and the maintenance system which has been developed using the steps described in the previous section, the user describes the system in LCOM terminology and runs the simulation. The procedures by which to accomplish an LCOM simulation are described in this section.

In the first versions of LCOM, the network descriptions of the weapon system were prepared by coding LCOM Forms 10, 11, 12, 13, and 14 to describe all the tasks and resources used. In later versions the Phase I Preprocessor was developed using the Extended Form 11 which allows the user to describe all the information about a task in the network on one form. This section will primarily cover the procedures to use the Extended Form 11. However, as an aid to those users who code the LCOM Forms directly, the following summary will be useful. Other users will probably wish to skip to Section IX-B on Extended Form 11 Coding.

A. Direct LCOM Coding - To describe the networks in the system, the user codes LCOM Forms 10, 11, 12, 13, and 14. These forms are:

1. LCOM Form 10. This form is used to identify the column headings under which the tabulated information on aircraft, men, equipment, and parts are to be displayed in the Performance Summary Report. The description of this form is found on page 8-18 of AFLC 70-1.
2. LCOM Form 11. This form describes the task interconnection selection mode. The coding of these forms is described on pages 8-2 through 8-5 of AFLC Report 70-1. The coding conventions discussed in Section IX-B.4 on Extended Form 11 Coding for task ID's and node names apply to this form.
3. LCOM Form 12. This form is used to describe the completion tasks times on the resources required for the task. The coding description is given on page 8-6 of AFLC 70-1.

4. LCOM Form 13. This form is discussed on page 8-8 of AFLC 70-1 and is used to describe the resources needed for the task.

5. LCOM Form 14. This form describes the failure clocks and is discussed on page 8-10 of AFLC 70-1.

Once the user has created a data package containing all of these LCOM forms, he proceeds to the section on creation of the maintenance data file, adds LCOM Forms 17, 18, and 19 and runs the input model.

B. Extended Form 11 Coding. - The use of the Extended Form 11 (Fig. 9-1) allows the user to describe most of the system on one form and use the Phase I Preprocessor to produce the necessary LCOM forms.

1. Extended Form 11 Parameter Card - The data package containing the Extended Form 11 must begin with a card called the parameter card. The parameter card is used to describe the general features of the network. All the entries on the parameter card are described in page 94 of Reference 4. However, the only fields on the parameter card which affect the Phase I input program are:

Columns 23-24 and Columns 29-30	The pre- and post-flight clock decrements, respectively. These values are used to determine the decrement values of the failure clocks used in the simulation. The value is in hundreds of sorties (i.e., 96 = .96). Its use is covered in the discussion of failure clocks.
Column 32	If a 2 is placed in this field, the distributions for the task times will be constant. Otherwise the distribution for each task is specified in Column 51 of Extended Form 11.
Columns 34-36	If specified, this datum gives the multiplier to the G selection mode probabilities (see discussion on Selection Modes, Section IX.B.7).



Columns 38-39      This is the average time to get resupply from depot, expressed in days. This information is used in the N action code processing (see discussion on N action code).

All other parameters are useful for identifying the data base but are not used by the Phase I program.

2. Network Header Card - The network header card identifies the network or portion thereof. This card is identified by an "H" in Columns 25 with the network clock in Columns 34 through 38. The network description can be put in Columns 41 through 66. The network clock must be the same as the system clock specified for each of the Extended Form 11 entries in the network. (See the description of System Clocks for a further discussion.) Columns 13 through 17 may also be used to specify resources to be generated in the network that follows.

e. The Extended Form 11 - The Extended Form 11 fields are described as follows:

Columns 5-10	The node name from which the task originates.
Columns 12-17	The identification of the task. This includes an action field (Column 12) and a work unit code field (Columns 13-17). A discussion of network identification is given later.
Columns 19-24	The node name to which the task leads.
Column 26	The task selection mode. (See Section IX.B.7 on selection modes.)
Columns 27-32	Task probability for A, E, or G selection modes for F selection modes. (See the discussion on selection modes.)
Columns 34-38	The network clock. This is discussed in the section on system clocks. (Section IX.B.6)
Column 39	An * in this column indicates that the task does not hold up the aircraft. This is usually a shop task for an LRU. At the completion of the network that

	follows this task, a resource is generated (an LRU is returned to Supply). This resource is identified by the work unit code field or on the header card.
Column 39	The task type as identified by LCOM (task types are shown in Appendix F).
Column 42	The relative priority of the task (refer to Appendix K for priorities).
Columns 43-47	The mean time for completion of the task. Left justified in tenths of hours (i.e., 12 = 1.2 hours).
Columns 48-50	The % variation in the mean task time. This field need not be filled in if distribution is C. For most maintenance networks the value of 29 can be used unless a better value is available such as preflight or weapons loading for which standards are established.
Column 51	The type of distribution function which describes the actual task time. This is automatically converted to C if Column 52 on the parameter card is set to 2. For the maintenance tasks the distribution of L can be used if a better distribution is not available. (Appendix R has a complete list of the available distributions.)
Columns 53 60 67 74	The quantity of the AGE or personnel resource indicated in the 5 columns following the quantity is recorded in one of these columns.
Columns 54-58 61-65 68-72 75-79	The column group 54-58, 61-65, 68-72, 75-79 is used to identify the resource. The AFSC for personnel resources (refer to Appendix I for a list of AFSCs as used by LCOM) or the AGE identifier for AGE resource.
Column 80	If a C appears in this column the next card is a continuation card. Columns 12-17 of the continuation card must be the same as Columns 12-17 of the original card. The resource fields (Column 53-79) have the same format as the original card and are used for specifying additional resources.

CAUTION: "ONLY ONE CONTINUATION CARD IS ALLOWED"

4. Extended Form 11 Coding Considerations - To insure correct coding of the Extended Form 11 the following conventions should be followed:

a. Task Identification - The task ID or name is generally arbitrary but each different task must have a unique name. To accomplish this, certain rules must be followed. First, all tasks which are network calls should begin with a C in Column 12 of the Extended Form 11 with CALLS1 being the call to the primary maintenance network. Refer to the discussion of the F mode selection for further description of CALLS1. All tasks which decrement failure clocks should begin with D in Column 12. (It is suggested that major failure decrement tasks be of the form DCRMTn and AGE failure decrement be of the form DCRMGN.) Sortie tasks should be labeled with Z00000. The rest of the tasks should use the LCOM action code and WUC as follows.

(1) Action Codes - The action codes for task identification are found in Appendix F. Only two of these codes affect processing of the Extended Form 11. They are:

Action Code Q: This action code causes an additional resource to be consumed and identified by the WUC established for this task.

Action Code N: This action code is an abbreviation for NRTS. If a task with this action code is found at the end of a network (i.e., Columns 19-24 are blank), a standard depot task is created with a task time as specified in Columns 38-39 of the parameter card.

(2) Work Unit Codes - The work unit code (WUC) field is used in the following way to insure unique task identification.

(a) Main Network - In the main networks the WUC field should contain a unique name to describe the task (page 32 AFHRL Vol II). The normal action codes for the network are: B, G, H, and J (refer to Appendix F).

(b) Unscheduled Maintenance Networks - All unscheduled maintenance networks begin with a task which has an action code and a mode selection of F. All tasks in this network should have the same four digit work unit code as described on page 53 of AFHRL Vol II. It should be noted that the Phase I Processor will connect all tasks with F selection modes to the primary maintenance network entry CALLS1.

(c) Multiply Defined Task - If the same task is found in different networks (this is particularly true in parts of the main network), they should have the same task name. However, subsequent reference to a task name on the Extended Form 11 should contain no resource allocation, since the same resources will be allocated to this task as the previously defined task.

5. Node Labeling - It is essential that the user exercise extreme care in selecting names for the nodes in the used LCOM simulation. Conventions have been established for labeling nodes. Should the user fail to follow these conventions he runs the risk of duplicating node names in any involved network. Since LCOM will connect all tasks with the same node name together, such a duplication would cause significant errors to be introduced into the simulation. These errors may remain undetected and thus result in faulty analysis of the weapons system. Even if the error is detected it will require time and additional computer reruns to correct the error. One rule the user must follow is not to use node names containing only numbers (Phase I uses numbered nodes to connect the maintenance networks to CALLS1). The other coding conventions that must be followed are different for the main networks and the maintenance networks.

a. Main Network Nodes - The six-character node name must consist of a one-to-three character code which identifies the network and a five-to-three unique sequence number, respectively.

b. Maintenance Network Nodes - Since the maintenance networks are generally the most complicated, a very rigid node naming convention has been established. This convention is described on page 55 of AFHRL Vol II and should be followed exactly.

6. System Clocks - The first purpose of the clock field (Columns 34-38) of the Extended Form 11 is to identify the network. The clock name is the same as the clock field for the network header. The clock which is assigned to the main networks is 00010 while all maintenance networks have clocks which are the same as the WUC of that network.

a. System Clocks for F Selection Tasks - The system clock takes an added significance for F selection mode tasks. These tasks test for the presence of a failure. The basic failure mechanism can be thought of as a clock that is utilized to trigger action within the network. This clock is first set to some value, then successively decremented by defined amounts when processing certain network tasks until the value is zero. At this time, a failure of some sort has occurred; information concerning the failure is stored where this clock is referenced in the network. The initial value of these clocks used in Extended Form 11 simulation is taken from an exponential statistical distribution whose mean is the value entered in the MSBF field of the F task that tests the clock.

Three decrement values for the clock are established for the user:

- (1) A decrement of 1.0 for the entire sortie.
- (2) A fractional decrement (less than 1.0) is recorded in card 23-24 for pre-sortie use.
- (3) A fractional decrement (less than 1.0) is recorded in card 29-30 for post-sortie use.



Decrements are constant per sortie and are not a function of sortie length. Phase I processing does not identify or produce the tasks which decrement these failure clocks. The user must modify the LCOM Form 14 output from Phase I processing to establish the decrementing tasks. The user may also modify the LCOM Form 14 output to specify different decrement values for each clock where the three decrement values from Phase I are not appropriate. The procedure covered in the section on modification to LCOM Form 14 describes the process that is necessary to do this.

7. Selection Modes - A detailed description of selection modes is given in Appendix J. However, certain selection modes require additional coding. These modes are:

A & E

These modes require that the probability of task execution be entered in the probability field (Columns 27-32). The number is entered in hundredths and is right-justified (i.e., the decimal point is assumed to be to the left of Column 31 such that 12 = .12).

G

The probability of task selection is also entered in Columns 27-32 for this selection mode. However, the decimal point is assumed to be to the left of Column 27 and this result is multiplied by the value entered in Columns 34 through 36 of the parameter card.

EXAMPLE: Suppose the parameter card contained a 10, then the entry shown in Fig. 9-2 would be read as .000321 and would be multiplied by 10 to give a G probability of .00321.

F

Since this task tests a failure clock, the Mean Sorties Before Failure (MSBF) is entered in Columns 27-32 as a right-justified whole number. The clock field (Columns 34-38) must be the same as the WUC field (Columns 13-17) or the task will not be processed.

Sel. Mode	MSBF or Probability							
	26	27	38	29	30	31	32	33
G					3	2	1	

Fig. 9-2. Task Probability Portion of Parameter Card.

C. Maintaining and Processing the Extended Form 11 - Once the Extended Forms 11 have been coded, keypunched, and verified, they must be processed by the computer. The procedure to be followed is described in general. The user should refer to Appendix O or P which discusses the uses of each of the programs on his computer system.

This procedure consists of three steps:

1. Creation of Updateable Data Base - The user can create an updateable data base, known as DBASE, by following the procedure shown in Fig. 9.3. The punch cards on which the Extended Forms 11 have been keypunched are submitted as input to the data base generating (DBG) program to create DBASE.

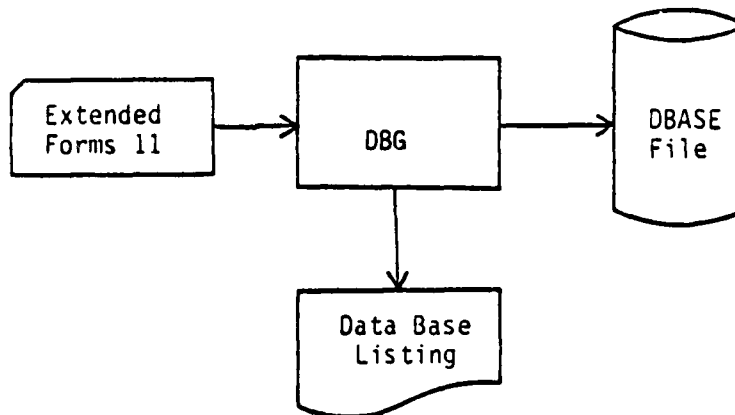


Fig. 9-3. Creation of Updateable Data Base.

2. Validation and Correction of the Data Base - Once DBASE has been generated the user may now begin the checkout procedure shown in Fig. 9-4. By using the data base updating (DBU) program the user may make changes to DBASE and thus produce a modified copy of DBASE. The latest copy of DBASE is used as input to Part One of the Phase I (P1) programs which perform the diagnostic checks shown in Appendix L. The user should then continue the process of modifying DBASE and running P1 until there are no diagnostics produced from processing the Extended Forms 11.

3. Generation of the LCOM Input Data Base - Once the DBASE is free from P1 diagnostics, it is ready to be processed by all the programs of Phase I to produce an input data base for LCOM as shown in Fig. 9-5. The final version of DBASE is processed by P1 and produces LCOM Forms 11, 12, 13, and 14 from the Extended Forms 11, which are written on a temporary file. Then Part Two of Phase I (P2) sorts the LCOM forms from this file according to form number and the LCOM Forms 14 are sorted according to clock decrement. (For a further description the user should refer to Section VII.D.2 which discusses the Form 14 entries.) This process produces the LCOM input data base, FDATA. This data base is then processed by the Phase I auxiliary program (AUX) to produce a listing of all the AFSC and AGE resources used in the data base. In the process of producing this listing, the AUX program provides a set of LCOM Forms 10, 13, and 16 for these resources on punch cards.

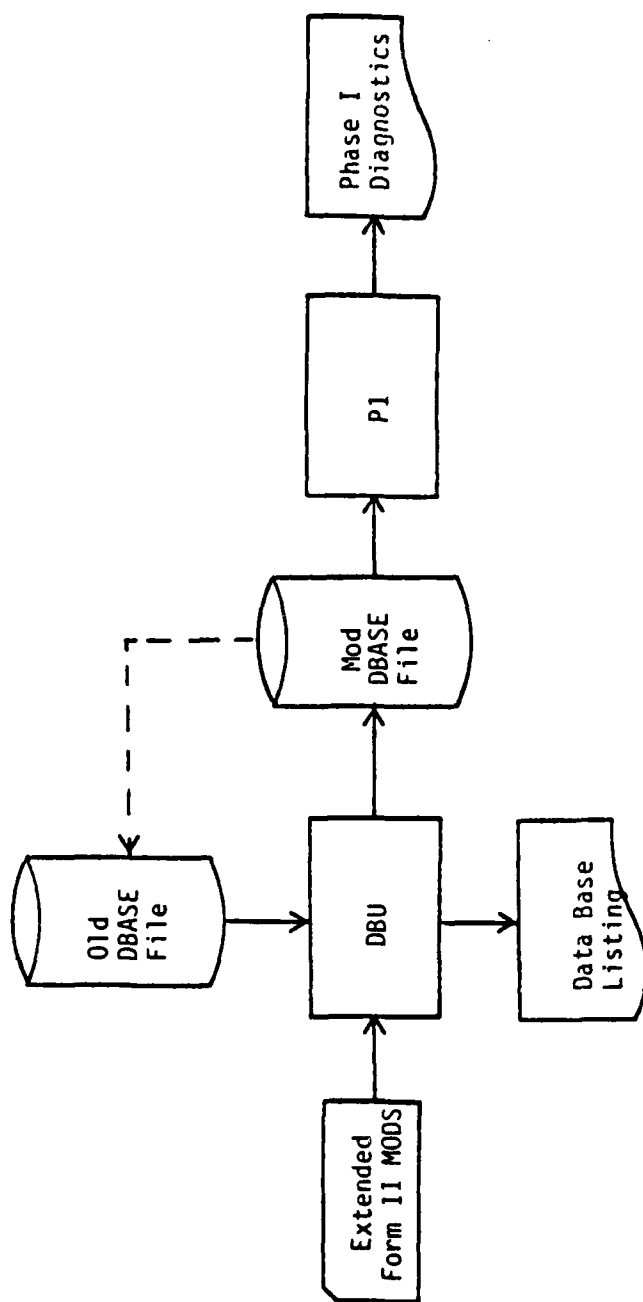


Figure 9-4. Validation and Correction of the Data Base.

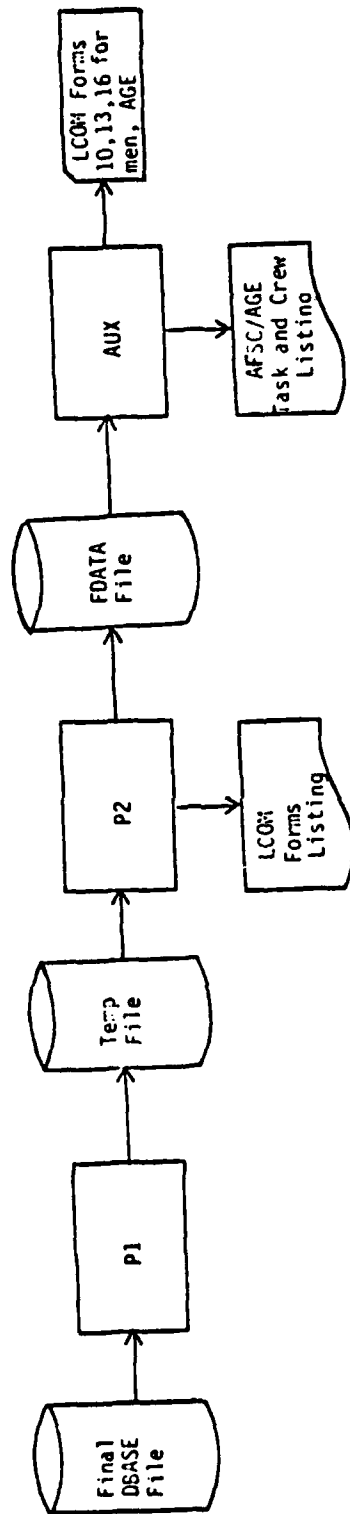


Figure 9-5. Generation of LCOM Input Data Base.

D. Creation of the Maintenance Input File - The maintenance input file produced by Phase I forms the basis of the input data to the LCOM input model that produces the maintenance data file. Before running the input model, the user must modify the LCOM Forms 11 and 14 in FDATA and add necessary LCOM Forms 10, 13, 17, 18, and 19 to FDATA. This is done by using the Data Base Updating program as shown in Fig. 9-6. The necessary modifications are:

1. LCOM Form 11 - Phase I connects all failure (F) selection mode tasks to the entry of the main maintenance network CALLS1. The user may have other maintenance networks on the simulation and, thus, must delete the LCOM Forms 11 which connect these tasks to CALLS1. In the listing of the FDATA data base, these forms will have an 11 in Columns 2-3, a three-digit number in Columns 8-10 (beginning node of the failure task), in Columns 19-24, and F in Column 26. If this type of Form 11 is deleted, the task is uncoupled from CALLS1. Coupling the failure mode tasks to the correct maintenance network may have been done when the Extended Forms 11 were coded; if not, they may be connected at this time by addition of an LCOM Form 11 to FDATA which contains an 11 in Columns 2-3, the maintenance network call name in Columns 5-10, the entry mode in Columns 19-24, and F in Column 26. For example, if the Extended Form 11 shown in Fig. 9-7 was submitted for Phase I processing, the resulting LCOM Form 11 would be shown in Fig. 9-8. Since the CAPGU node is already the entry to a called network, the connection to CALLS1 in line 4 should be deleted. The connection to CALLS1 in line 6 is retained since it is properly connected to the primary maintenance network. The task in line 8 which connects TTU04 to CALLS1 needs to be deleted. We are assuming that this task is supposed to be converted to CALTTU and replaced by a task which connects it to CALTTU. The resulting data base is shown in Fig. 9-9 where line 7 is the added LCOM Form 11 to connect ATTU04 to CALTTU.

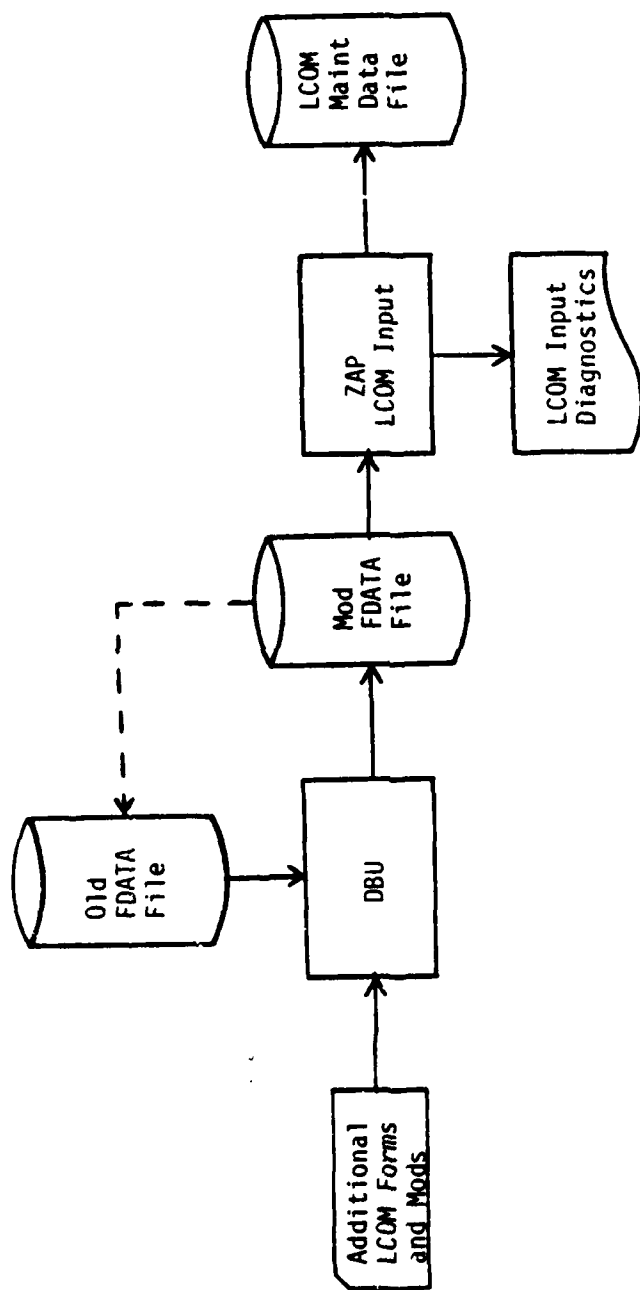


Figure 9-6. Creation of the Maintenance Input File.

[illegible]



	PRIOR NODE										TASK I. D.										NEXT NODE										SEL. MODE
	CARD I. D.	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26				
		1	1	1		J	0	0	1	3	5		C	A	I	G	P	U		J	0	0	1	3	7		C				
		1	1	1		C	A	L	G	P	U		F	A	G	F	0	0		A	D	6	0	0	5		F				
		1	1	1		C	A	L	L	S	1												1	0	1		F				
		1	1	1					1	0	1									C	A	I	G	P	U		F				
		1	1	1			D	1	A	0	0		F	4	1	A	0	0			D	1	A	0	C		F				
		1	1	1					1	0	1										D	1	A	0	0		F				
		1	1	1		A	T	T	U	0	4		F	T	T	U	0	0		A	T	T	U	0	5		F				
		1	1	1					1	0	1									A	T	T	U	0	4		F				

Figure 9-8. Resultant Form 11.

(1)  
(2)  
(3)  
(4)  
(5)  
(6)  
(7)  
(8)

CARD I.D.	PRIOR NODE										TASK I.D.										NEXT NODE										SEL. MODE
	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26					
	1	1	1		J	0	0	1	3	5		C	A	L	G	P	U		J	0	0	1	3	7		C					
	1	1	1		C	A	L	G	P	U		F	A	G	E	0	0		A	D	6	0	5	5		F					
	1	1	1																			1	0	1		F					
	1	1	1			D	1	A	0	0		F	4	1	A	0	0			D	1	A	0	C		F					
	1	1	1					1	0	1										D	1	A	0	0		F					
	1	1	1		A	T	T	U	0	4		F	T	T	U	0	0		A	T	T	U	0	5		F					
	1	1	1		C	A	L	T	T	U									A	T	T	U	0	4		F					

Figure 9-9. Modified Form 11.

2. LCOM Form 14 - Phase I processing produces an LCOM Form 14 for all failure clocks referenced in Extended Form 11 failure (F) tasks. However, the Phase I programs do not identify the task which decrements the clock. The user must assign the decrementing task to the LCOM Form 14 and delete the unnecessary entries.

EXAMPLE: If we consider the Extended Form 11 entries shown in Fig. 9-7, and the following assumptions:

- a. The pre-sortie decrement on the parameter card is .90.
- b. The post-sortie decrement on the parameter card is .10.
- c. The clock referenced in task FAGE00 is to be decremented by task DCRMG1 by a value of 1.
- d. The block referenced in task F41A00 is to be decremented by task DCRMT1 by the pre-sortie decrement and by the post-sortie decrement from DCRMT7.
- e. The clock reference in task FTTU00 is to be decremented the same as F41A00.

The resulting LCOM Forms 14 produced by Phase I from Extended Form 11 entries are shown in Fig. 9-10.

From assumption c, we see that lines 1 and 4 must be deleted and line 3 must be replaced with an identical record containing DCRMG1 in Columns 5-10. Using assumptions a, b, d, and e, lines 8 and 9 are deleted and lines 2 and 5 are replaced with identical records containing DCRMT7 and DCRMT1 in Columns 5-10, respectively. The resulting LCOM Form 14 is shown in Fig. 9-11.

3. LCOM Form 10 - The Phase I Processor produces LCOM Form 10 for all spares used in the simulation (i.e., WUC identified LRUs from Q type tasks) for the DDATA database. The Phase I auxiliary programs provide the user with a set of Form 10s for AFSC and AGE resources which normally can be put directly into the FDATA data base. Thus, the user needs to provide only LCOM Form 10s for aircraft and missions.

	CARD I.D.		TASK I.D.								MODE		RESOURCE I.D.										DECREMENT					
	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26		
(1)		1	4									C		F	A	G	E	0	0							1	0	
(2)		1	4									C		F	4	1	A	0	0							1	0	
(3)		1	4									C		F	T	T	U	0	0							1	0	
(4)		1	4									C		F	A	G	E	0	0								9	0
(5)		1	4									C		F	A	1	A	0	0								9	0
(6)		1	4									C		F	T	T	U	0	0								9	0
(7)		1	4									C		F	A	G	E	0	0				1			0		
		1	4									C		F	4	1	A	0	0				1			0		
		1	4									C		F	T	T	U	0	0				1			0		

Figure 9-10. Resultant Forms 14.

	CARD I.D.				TASK I.D.							MODE	RESOURCE I.D.							DECREMENT						
	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26
(1)		1	4		D	C	R	M	I	7		C		F	4	1	A	0	0						1	0
(2)		1	4									C		F	I	I	U	0	0						1	0
(3)		1	4		D	C	R	M	I	1		C		F	4	1	A	0	0						9	0
(4)		1	4									C		F	I	I	U	0	0						9	0
(5)		1	4		D	C	R	M	G	1		C		F	A	G	F	0	0			1		0		

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Figure 9-11. Modified Forms 14.

For each area of the LCOM Form 10, the number of column headings and the column heading entries are required to provide the column headings for the PSR. In the first entry, the number of headings is entered in Columns 7-8 and on the second the heading names are entered in Columns 7-12, 13-18, 19-24, 25-30, 31-36, 37-42, 43, 48, 49-54, 55-60 and 61-66 which allow 10 headings per card. (If the number of headings exceeds 10, additional cards must be used.)

- a. LCOM Form 10 Mission Category - The mission categories correspond to mission I.D. use in LCOM Form 17. The number of headings for mission categories is entered on a Form 10 with a 10 in Columns 2-3, and a 2 in Column 5. The headings to be used for each of the mission categories are entered on a Form 10 with a 10 in Columns 2-3, and a 3 in Column 5.
- b. LCOM Form 10 Aircraft Entries - This is the identification of the different aircraft to be listed as the performance summary report. These headings correspond to the column number for all aircraft entered in LCOM 13 Forms for the simulator. The number of aircraft headings is entered as an LCOM form with 10 in Columns 2-3, and a 4 in Column 5, and the headings are entered on an LCOM form with 10 in Columns 2-3, and a 5 in Column 5.
- c. LCOM Form 10 Maintenance Area Groups - These LCOM forms are produced along with the corresponding LCOM Forms 13 to give headings to the AFSC. Normally the user will not have to change these forms, but should it be necessary the AFSC headings have the same format as the other heading Forms 10.
- d. LCOM Form 10 Supply - The Phase I Processor produces these forms with separate headings for the first 399 LRUs and puts all the remaining LRUs under the heading of OTHERS. These forms are on the FDATA data base and normally do not need to be modified.

e. Equipment Categories LCOM 10 - The Phase I auxiliary program produces an LCOM 19 output for AGE which is similar to the AFSC output. These cards are normally sufficient unless different headings are needed.

4. LCOM Forms 13 - The Phase I auxiliary programs produce LCOM Forms 13 as cards for all AFSCs and AGE used in the Extended Form 11. The only modification needed is to add substitute resource names in columns 29-34 where there is a substituted resource (care should be used in substituting resources). For AGE Forms 13 the user may wish to change the authorized quantity in columns 24-27 from the unconstrained value of 100. However, since the authorized quantities may be changed at the time of simulation, this is probably the best value to submit to the input model.

a. LCOM Form 13 for Aircraft - For each type of aircraft used in the simulation the user must add an LCOM Form 13 to the FDATA data base.

Each form is constructed as follows:

Col 2-3	13
Col 5-10	The aircraft type. (This name is used in LCOM Form 20)
Col 12	1
Col 14-15	A number which corresponds to the proper heading in the performance summary report (LCOM Form 10).
Col 24-27	The number of authorized aircraft. May be changed during simulation.

5. LCOM Forms 16 - The Phase I auxiliary programs produce LCOM Form 16 for eight-hour shifts/seven days a week for each AFSC entered in Extended Forms 11. The Form 16 can also allocate up to 200 people per shift. If more complicated shifts are desired then user should code LCOM Forms 16 as described on pages 8-14 of AFLC Report 70-1. During the simulation phase the shift authorization may be changed to constrain the problem.

6. LCOM Forms 18 - The exact use of LCOM Forms 18 is described on pages 8-20 of AFLC Report 70-1. A header card with an accompanying Form 18 is shown in Fig. 9-12.



01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17	18	19	20	21
	1	8																		
	1	8	0	4		1						1						0		
	1	8	0	6		.	4	8				.	4	8				.	4	8
	1	8	0	7			5	0				1	0	0				1	0	0
	1	8	0	8		.	9	9												

Figure 9-12. Suggested Forms 18.

7. LCOM Forms 17 - The LCOM Form 17 is used to define the mission entry points and optionally, the configuration required for the aircraft. (The configuration control option is not necessary.) These forms must be added to the FDATA data base. The LCOM Form 17 format is:

Col 2-3	17
Col 5-10	Mission ID. This is the name that is used in the LCOM Forms 20.
Col 12-13	The column number is the performance summary corresponding to the mission entry headings on the LCOM Form 10. Blank and bad entries will cause the mission to be entered in the last column (beyond those specified by LCOM Form 10) in the performance summary report. A zero will cause the mission to be omitted from the performance summary report.
Col 22-41	These entries control the configuration of the mission aircraft. No entries are necessary if the user is not using configuration control. If configuration control is used, then LCOM Forms 19 are also required. The configuration control field contains:
Col 22-27	The configuration class of the aircraft required for the mission. A blank configuration defaults to the first defined configuration.
Col 29-34	The aircraft configuration at the end of the mission.
Col 36-41	The search pattern which describes the sequence of configuration classes to be searched in order to obtain an aircraft for the mission. The search patterns must be described on Form 19.

8. LCOM Forms 19 - The forms are needed only if the user has chosen to use configuration control. The format of the LCOM Form 19 is:

Col 2-3	19
Col 5-10	The name of the search pattern is referenced in columns 36 through 41 of LCOM Forms 17.
Col 11	If a C is found in this column then the form is a continuation of the previous form.

Col 12-17	The first configuration to be selected.
Col 18-23	The entry node to a network which will reconfigure the aircraft.
Col 24-29 36-41 48-53 60-65	Subsequent configuration classes from which the aircraft may be selected.
Col 30-35 32-47 54-59 66-71	The corresponding entry nodes for reconfiguration of the associate class of aircraft.

a. General Notes on LCOM Form 19:

- (1) The search pattern (ATTRIT) defaults to a search of all classes unless redefined by an LCOM Form 19.
- (2) A maximum of 10 configuration classes can be handled by LCOM.

CAUTION: THE MODEL ASSUMES THE FIRST CLASS READ FROM THIS FORM TO BE THE DEFAULT (NONCONFIGURED) CLASS.

- (3) The user should define the search pattern to search the required or same mission class first. This action precludes the possibility of a lot of undesirable reconfiguration being done by the model.
- (4) If the selected configuration is the same as the required configuration class, the reconfiguration entry mode is ignored.

9. General Considerations

- a. LCOM forms must be grouped by form number. Thus LCOM forms 11, 14, and 13 must be added to FDATA in the area where those LCOM forms are located and LCOM Forms 16, 17, 18, and 19 must be placed in the FDATA data base behind LCOM Form 14.

b. Each of the sets of LCOM Forms 16, 17, 18 and 19 must be preceded by an equivalent LCOM form header which has the form number in columns 2, 3.

c. The last record in the data base must contain 999999 in columns 1 through 6.

Once the necessary modifications have been made to the FDATA data base then the input model (ZAP) is run to produce the maintenance data file. This run produces a diagnostics output which allows the user to again modify FDATA and rerun ZAP until the maintenance input file is correct.

E. Creation of the LCOM Operation Data File - The LCOM Operation Data File is created by the user on Form 20 to run the LCOM input model to produce an "exogenous events tape" to make the Operation Data File (ODF). This procedure is shown in Fig. 9-13 and includes the submission of LCOM Forms 15 and 20.

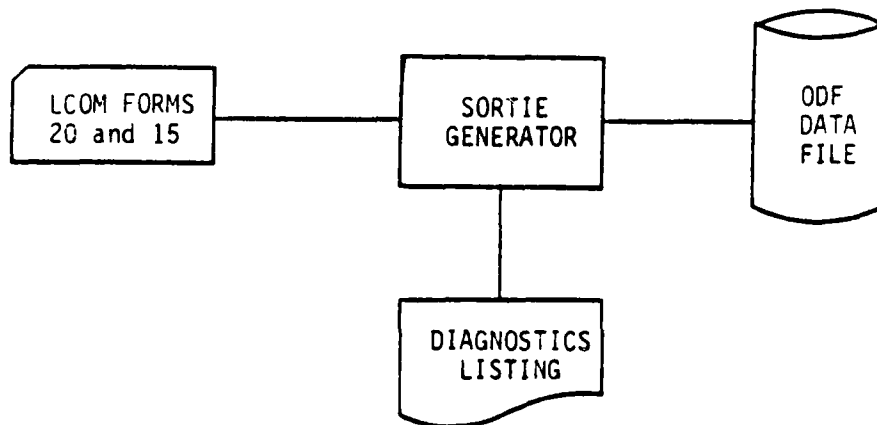


Figure 9-13. Creation of the LCOM Operation Data File.

1. LCOM Forms 15 - These forms allow the user to tabulate distribution for use in the Form 20. If no tabulated distributions are used these forms do not need to be submitted. The format of this form is:

Col 2-3	15
Col 5-7	The distribution ID which is used to reference the distribution on the LCOM Forms 20.
Col 9	Specifies the type of distribution I - indicates that LCOM is to interpolate S - indicates that the distribution is a step function
Col 11	Specifies the format of the distribution values H - hours M - minutes
Col 13-16 23-26 33-36 43-46 53-56	The tabulate probabilities. This tabulation is a cumulative probability (i.e., is range from a value of 0 to 1.
Col 17-22 29-32 37-42 47-52 57-62	The value of the parameter for which the probabilities are as found in 13-16, 23-26, 33-38, 43-46, and 53-56, respectively.
Col 64-66	Will modify the values entered in columns 17-22, 23-32, 37-42, 47-52, and 57-63 by this constant amount if entered.

a. Continuation - The distribution descriptions may be continued on additional Forms 15s by leaving columns 5-11 blank.

2. LCOM Form 20 - The actual description of the operations is described on the LCOM Form 20. The format is:

a. Header Card - The first card of the Form 20 group contains a 20 in columns 2-3 with header information allowed on the rest of the card.

b. Control Card - The control card identifies the amount of flying schedule to generate. The format is:

Col 1-3	Card ID - If a listing of mission data is to be generated, the ID must begin with L.
Col 5-7	The number of days for which operations data is desired.
Col 9-14	A six-character identifier which can identify the operation data. This is also required.
Col 16-73	Additional user information, as desired.

c. Mission Data - The rest of the LCOM Forms 20 have the same format and they describe the different missions as follows:

Col 2-3	20
Col 5-7	The day on which the mission is to occur. These mission requirements must be entered in ascending order of days beginning with 0 (not all days must be entered).
Col 9-12	The number of missions to be flown during the day. If blank, it is assumed to be 1.  If the user wishes to specify a statistical distribution for the number missions, he may enter an asterisk (*) followed by the tabulated distribution number entered in columns 5-7 of an LCOM Forms 15.
Col 15-18	The takeoff time as a four-digit time of day. The user may enter an asterisk on a distribution number for a random takeoff time. For multiple takeoffs for the same mission enter an R followed by LCOM Forms 20 for each mission (number of these forms must be equal to the number of missions in columns 9-12).

Col 20-25	The aircraft identification coded exactly as found in columns 5-10 of the LCOM Form 13 for that aircraft.
Col 27-32	The mission ID as entered in columns 5-10 of the LCOM Form 11.
Col 34-35 36-37 38-39	The minimum and maximum number and number of spare aircraft to be allocated for the mission.
Col 41-46	The mean mission length in hours for a standard distribution. If a tabulated distribution is used an asterisk followed by the distribution number is entered in this field.
Col 47-52	The variance for standard distributions in hours.
Col 53	The distribution of mission lengths. Refer to Appendix R for list of distributions.
Col 55-58	The time that is needed before takeoff to begin the mission (in hours).
Col 60-63	The delay time after takeoff time which can cause the mission to be cancelled (in hours).
Col 65-66	The mission priority (0 highest, 9 lowest).
Col 68-70	The repetition interval for the specified mission (i.e., if 1 is entered the missions are repeated every day and if 3 the missions are repeated every 3 days).
Col 71-73	The number of days the repetition is to continue.

F. The LCOM Simulation Run - Once the maintenance input and the operations data file have been created, the user is ready to run the simulation, following the procedure outlined in Fig. 9-14.

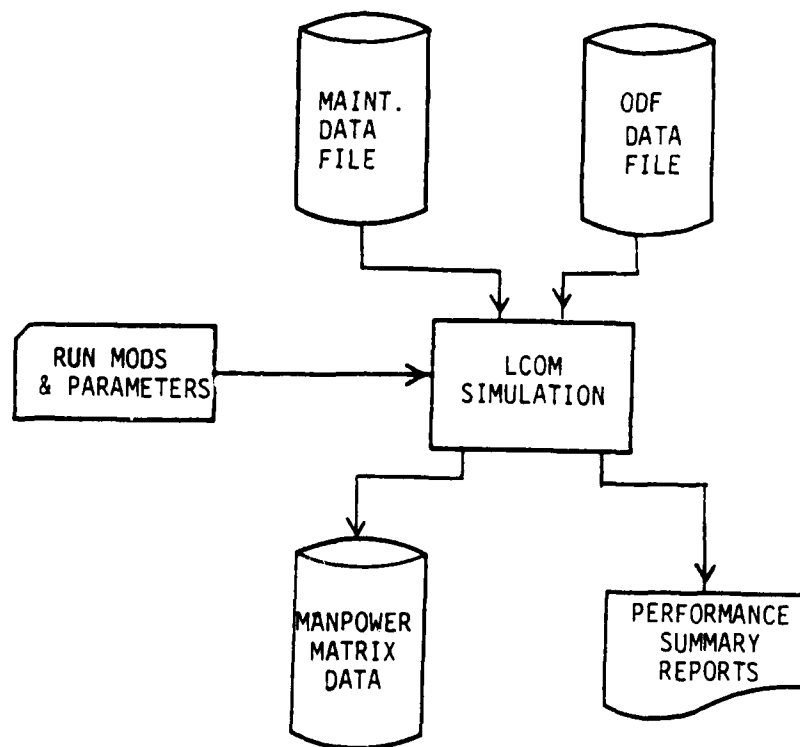


Figure 9-14. The LCOM Simulation Run.



The input necessary to the simulation model is described in AFLC reports 70-1 and 74-1, but the most useful simulation data are described below.

1. LCOM Simulation Change Cards - The change cards have the following format:

COLUMNS	NAME	DESCRIPTION	POSITION
1-6	VNAM	Variable Change Name	Left-Justified
7-12	IPAR	Integer Parameter	Right-Justified
13-25	FPAR	Floating Parameter	Decimal point in Col. 19
26-31	IAPAR	Alpha Parameter	Left-Justified
32-37	KTAPE	Integer Parameter	Right-Justified

- a. LCOM Change Variables - The use of these change cards varies with the change variables. The most often used change cards are:

- |        |   |
|--------|---|
| STOP   | This type of change card is the only required change card for the simulation. The FPAR field indicates the number of days to be simulated. All others are optional.   |
| AUTH   | This variable allows the user to change the authorized amount of resources in the simulation. This equivalently changes the value in Col. 24-27 of the LCOM Form 13 for the resource. IPAR is the resource number as found in the output from the LCOM input model and FPAR specifies the new authorization.  |
| 48     | This variable specifies when a cumulative control table hit matrix is to be output. FPAR indicates the output time in days.   |
| SAUTH  | This variable allows the user to change the authorized quantities for resources which have been initially assigned shifts. This is effectively changing the authorization in LCOM Forms 16. IPAR is the resource number as found in the printout of the input model. FPAR is the shift number from the beginning and KPAR is the new authorization. |
| REFREQ | This change parameter specifies the frequency in days that the performance summary report should be made. This frequency is entered in FPAR.  |

RCYC	This variable specifies in IPAR the summary report that will be issued before an overall summary report will be issued.
PCT	Specifies the remaining processing time factor in FPAR by which an interrupted task will be increased. This changes any entry on type 09 LCOM Form 18.
SWICH	When 101 appears in IPAR it is the time in days into simulation when the cannibalization feature is activated, as found in FPAR.  When 123 appears in IPAR then FPAR contains the time in days that the manpower matrix is produced on File 11.  When 120 appears in IPAR then the time in days specified in FPAR is when manpower matrix ceases.
MNSTAT	The time in days, in FPAR, when a mission status report is to be requested.
ITEM	The time, in FPAR, is the requested time for a resource status report.
BOSTAT	A back order status report is to be requested at the time specified in FPAR.

Additional change cards are found on pages 8-30 through 8-34 of AFLC 70-1 and pages 2-13 through 2-14 of AFLC 74-1.

b. General Considerations

- (1) The simulation model should be run without requesting matrix output until the necessary parameters have been set and the simulation checked out.
- (2) The cannibalization procedures (SWICH 101) should be activated early in the simulation.

G. Manpower Matrix Output - Once the simulation run has been checked out the user is ready to produce the Manpower Matrix. The output is turned on by a SWICH 123 card and off by a SWICH 120 card. The output for

the manpower matrix should be turned on after the simulation has stabilized (about 23-30 days of simulation). The simulation should be run for a sufficient length of time to get a good distribution. The manpower matrix is produced by processing the manpower matrix by the MX program as shown in Fig. 9-15. The input parameters to the MX program identify the AFSCs for which the matrix is produced.

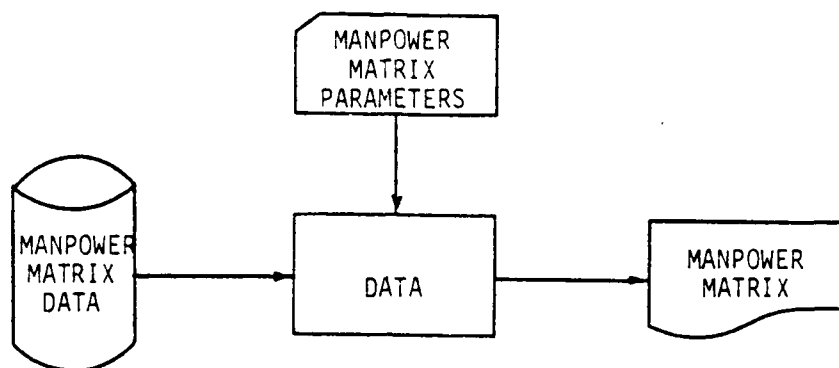


Figure 9- 15. Manpower Matrix Program.

1. Manpower Matrix Parameter Card - The first parameter card at the end of the MX deck is set up as follows:

Col 2-4	Total number of AFSCs as specified on the LCOM 10 06 card in the input processor file.
Col 5-7	Start day of matrix, as indicated on the SWICH 123 card, whole number, right-justified, no decimal.
Col 8-10	Stop day of matrix, as indicated on the SWICH 120 card in the LCOM simulation run deck.

The rest of the parameter cards for the MX run specify the AFSCs and report columns in the order entered on the LCOM 13 cards. They are entered in eight column block across the entire card. The first five columns of each block give the AFSC while the last two specify report column. For example:

Col 1-5	First AFSC
Col 7-8	01
Col 9-13	Second AFSC
Col 15-16	02

Additional cards follow specifying report columns 11-20, 21-30, etc., as needed. This procedure will produce the manpower matrix discussed in Section X on Reports.

H. Moody Manpower Programs - The manpower requirements for any LCOM simulation can be determined by using the procedure outlined on pages 111-126 of AFHRL-TR-74-97 (II). Normally this information is required for a large range of mission requirements (usually measured in terms of flying hour or sorties flown per month). It is both costly and time consuming to run LCOM simulations for all levels of mission activity, therefore the Moody Manpower Programs were developed to calculate the manning requirements for any reasonable level of mission activity.

NOTE: THE MOODY MANPOWER PROGRAMS ARE FOR USE  
ON CDC-6600.

Examples of control cards necessary to run the programs are described in Appendix O. The two parts to the set of programs are:

1. Manpower Regression Program - The manpower regression program produces the coefficients of a third order polynomial which describes the variable manning as a function of either flying hours or number of sorties flown. (Example:  $M_r = A + B y + C y^2 + D y^3$  where  $y$  is flying hours and A, B, C and D are the coefficients produced.) The regression program operates in two modes to produce these coefficients.

a. Simple Regression Mode - In the simple regression mode the analyst can produce the coefficients mentioned from the manpower data of five LCOM simulation runs. For each work center the analyst must determine the manning requirements for five different levels of mission activity. (The levels of mission activity should cover the range of interest.) The input to the regression program consists of two files. For the simple regression the input should be:

(1) Input File 1 - This input file contains the control parameters which select the mode of regression. In the case of simple regression there is only one card with the following format:

Col 1	0
Col 5	0

(2) Input File 2 - The second input file contains the data for each work center being used with the format as follows:

Col 1-5	The level of mission activity for each of five LCOM simulations (either as flying hour or number of sorties per month). It may appear anywhere in the field but must contain a decimal point, explicitly included, or it is assumed to be to the right of the last column of the field.
11-15	
21-15	
31-35	
41-45	
Col 6-10	These fields contain the manpower requirements as determined from the corresponding LCOM simulations for which the mission levels were given. They have the same format as the mission activity fields.
16-20	
26-30	
36-40	
46-50	
Col 51-56	The field is not used by the regression program but is punched with the coefficients for identification of the card.
	The AFSC is normally entered in this field. It is left-justified in the field.
Col 59-74	This field is also used for identification of the coefficients output and normally contains the function code.

- Col 68-70      This field contains minimum manning required for the work center. The number must be right-justified in the field. This parameter is not used by the regression routine but is punched with the regression coefficients for use by the manpower program.
- Col 74-75      This field contains the sequence number for this work center which is used by the manpower program.
- Col 79-80      This field contains an optional factor which will change all manning requirements by a constant amount. This number must be entered with the decimal point.

b. Curve Shifting Mode - Many times it is not economical to generate five LCOM simulations required by the simple regression. In this case it is desirable to be able to shift the data from an existing curve which is similar to correspond to a single new point. The curve shifting mode accomplishes this task. The analyst provides the program with the regression coefficients of the existing curve and five data points, of which four are from the existing curve and the last is for the shifted point. The program calculates the manning value from the coefficients at the new point and uses the new manning requirements for the point to calculate a multiplicative shift. All the points from the original curve are shifted by this factor and the regression coefficients are calculated from these points. For this mode of operation the input files have the following formats:

(1) Input File 1 - This file now not only selects the curve shifting mode but provides the program with the coefficients needed. There are the control card and coefficient control cards.

(a) Control Card

- Col 1            This field contains the number of the point which forms the basis for the shifting (i.e., the new point). Acceptable numbers are 2, 3, and 4.
- Col 5            If col 1 contains 3, then a 4 in this field will cause only point number 2 if the data points are to be shifted.

NOTES: 1 The new point must be the same on all the data input cards.

2 The current AFTEC version does not shift the first point which is assumed to be the intercept.

(b) Coefficient Cards - For each set of data points found in the second input file a coefficient card must follow the control card. The format is:

Col 1-11	This field contains the intercept. This and other coefficient cards must be punched with an explicit decimal point.
Col 12-22	This field contains the coefficient of $(.01y)$ .
Col 23-33	This field contains the coefficient of $(1.01y)^2$ .
Col 34-44	This field contains the coefficient of $(.01y)^3$ .
Col 79-80	The AFSC sequence number which corresponds to the entry in column 74-75 of the corresponding data card. This number must be less than or equal to 18 (40 at AFTEC) and is right-justified.

NOTE: These coefficient cards may be from the output of the regression program.

(2) Input File 2 - The second input file contains the sets of data points used in the curve shifting. The format is the same as the second input file, except as follows:

(a) All mission level and manpower fields, except the field identified in col 1 of the control card contain the data points from which the original coefficients were calculated.

(b) The mission line and manpower fields corresponding to the entry on the control card contain the new data point (2 = col 11-15 for mission level and 16-20 for manpower, 3 = col 21-15 and 26-30, respectively; and 4 = col 31-35 and 36-40, respectively).

(c) The old data points need not be in the same order as for the original calculation.

(d) The AFTEC version does not shift the first field (column 6-10) and this is assumed to be a constant intercept data point.

c. Regression Program Output - The regression program produces coefficients when operating in either mode. The coefficients are punched on cards having the following format:

Col 1-11	The intercept.
12-22	The coefficient of $(.01y)$
23-33	The coefficient of $(.01y)^2$
34-44	The coefficient of $(.01y)^3$
46-50	The field containing the AFSC information entered in columns 51-56 of the corresponding data card.
54-59	This field contains the function code information from columns 59-74 of the corresponding data card.
79-80	This field contains the AFSC sequence number used by the curve shifting mode and by the manpower program.

2. Manpower Program - The manpower program produces the manning authorization for maintenance at the desired level of mission activity. The program uses the coefficients from the regression program to compute the direct manning requirements and determine the minimum manning levels. The program also uses a file which describes maintenance organization and the manpower requirements for the fixed overhead personnel.

a. Input Requirements - The manpower program uses three input files called INPUT, TAPE2, and TAPE8 on the CDC-6600 system. Their formats are:



(1) The INPUT File - The INPUT file contains two program control cards:

(a) Control Parameter Card - The card controls the operations of the program and has the following fields:

- |         |  |
|---------|--|
| Col 1-6 | This field contains the number of flying hours per month in thousands of hours. If non-zero then this value is used to calculate the variable manning. If flying hours are used then the regression coefficients must have been calculated in terms of flying hours. If 0.0 is entered, then the sortie rate field is used to calculate variable manning. If the decimal point is not explicitly included it is assumed to be between columns 3 and 4. |
| 7-8     | This field contains the number of unit equipment (UE). Acceptable inputs here are 18, 24, 36, 48, 54, 72, and 96. The job is aborted if an unacceptable value is in these columns. This input is used as part of the header printout, also to determine which columns are used for finding the standard input values for the grade index and authorized manning.   |
| 12-13   | This field is the output control parameter. A regular printout and a Basic Authorization (BA) card deck are produced if a -2 is entered. A regular printout only is produced if a -1 or 0 (blank) is entered. If diagnostic printout is desired in addition to the regular printout, a 1 should be entered. Finally if the diagnostic printout is desired in addition to the regular printout and BA deck, a 2 must be entered.                        |
| 14-16   | The current quarter and year for output on BA punched deck is entered in this field.<br>Example: 176.  |
| 17-23   | This field contains a left-justified name of scenario strictly for printout of header for listing.   |
| 24-25   | Utilization rate (UR) is found in this field. This must be entered as an integer right-justified in the field.<br><br>When using flying hours, $UR = \text{Flying Hours}/UE$ .<br>When using number of sorties, then $UR = \text{Number of Sorties}/UE$ .<br>This field, however, is used in the output only.  |

Col 26-28	This field contains the sortie rate. If the flying hours field is zero then the value is used to calculate the variable manpower requirements. If the sortie rate is used then the regression coefficients must have been calculated using sorties flown per month. The number must contain a decimal point.
29-31	The sortie length in hours for the output header is entered here. Number must contain a decimal point.
32-34	This field contains the aircraft identifier for listing header, e.g., A7D.
35-39	A heading to be used for the UR summary if used is found in this field.
60-62	This field contains the initial utilization rate for summary. If non-zero, the program will calculate the total manpower requirement for several utilization rates. The number must be right-justified in the field.
63-65	The last UR for the summary manpower table, right-justified is entered in this field.
66-67	The size of the UR increments in making the summary table is entered in this field.
70-75	The program element code (PEC) is entered in this field to be punched in the BA deck.
80	If an N is entered in this field the program will not calculate the supervisory manning requirement for the variable manpower work centers. If left blank, the program will add a 2.96% overhead for supervisors.

(b) AFSC Grouping Control Card - This card allows the analyst to instruct the manpower program to group all the 9-level AFSCs from several work centers (maximum of 4) together with one of the work centers. (The first listed in the group). The format of this card is:

Col 1	Number of work centers for first AFSC group ≤ 4.
-------	---

Col 2-5	Work centers in first group
4-5	(number corresponds to sequence number
6-7	on coefficient parameter cards)
8-9	Right-justified
21	Number of work centers in second group
22-23	Work centers in second group
24-25	
26-27	
28-29	28
41	Number of work centers in third group
42-43	Work centers in third group
44-45	
46-47	
48-49	
61	Number of work centers in fourth group
62-63	Work centers in fourth group
64-65	
66-67	
68-69	

These cards allow grouping of work centers with the same AFSC for calculation of supervisors.

(2) The TAPE2 File - This file contains the regression coefficients produced by the regression program. The format is described in that section. This file must contain 40 cards and the sequence number (col 79-80) must correspond to the card position or the program will abort. These coefficient cards must be in the same order as they are to be used in references from the TAPE8 file. Unused cards at the end may be blank, except for the sequence numbers.

(3) The TAPE8 File - This file contains the description of all the personnel required for a maintenance unit and provides the authorization levels for the fixed overhead. There is at least one card for each AFSC and grade needed. The format for each card is:

- Col 1-6 This field contains a six-digit function code describing the organization (refer to next section concerning its use).
- 7-36 A description of up to 30 characters of the function code as entered in this field.
- 37-41 This field contains the organizational structure code. It must be entered left-justified.
- 42-47 The Air Force specialty code (AFSC) for the position. Left-justified.
- 48-50 Normal grade designation. (The actual grade will be determined by the manning authorization, if fixed manning.)
- 51-78 This field contains the fixed manpower authorization as a function of UE. The authorization for each unit strength is for a grade (denoted by grade index codes) and an authorized strength. If a card represents fixed manpower then a grade index must be entered for each unit strength that will be used.

This field is left blank if the manpower authorizations are to be calculated from the regression of coefficients. Then authorizations are obtained from each set of coefficients and represent grade indexes 7 through 16 (in that order). The manpower authorization for variable manning is calculated from the coefficients in the order they are found in the TAPE2 file.

The index codes for grades used are:

1 = COL	7 = CMS	12 = SSG
2 = LTC	8 = SMS	13 = SSG
3 = MAJ	9 = MSG	14 = SGT
4 = CPT	10 = MSG	15 = A1C
5 = LT	11 = TSG	16 = A1C

NOTE:

- (a) Code index 9 refers to a 9-level MSG and index 10 refers to a 7-level MSG.
- (b) Index 12 refers to a 7-level SSG while 13 refers to a 5-level.

(c) Grade index 15 refers to a 5-level A1C  
and index 16 to a 3-level A1C.

All entries in the fixed manpower authorization  
field are right-justified.

The fields for the fixed manning authorization are:

Col 51-52	Grade index for an 18 UE unit.
53-54	Authorized manning for an 18 UE unit.
55-56	Grade index for a 24 UE unit.
57-58	Authorized manning for a 24 UE unit.
59-60	Grade index for a 36 UE unit.
61-62	Authorized manning for a 36 UE unit.
63-64	Grade index for a 48 UE unit.
65-66	Authorized manning for a 48 UE unit.
67-68	Grade index for a 54 UE unit.
69-70	Authorized manning for a 54 UE unit.
71-72	Grade index for a 72 UE unit.
73-74	Authorized manning for a 72 UE unit.
75-76	Grade index for a 96 UE unit.
77-78	Authorized manning for a 96 UE unit.

b. Manpower Output - The program will read the TAPE8 field and will  
print out the manpower requirements for each entry that is greater than  
zero (either through fixed requirement for the TAPE8 file for the unit  
strength or from variable manning calculations).

The program will process five different functional areas which are identi-  
fied by different initial 2 digits in the functional code. (NOTE: All  
TAPE8 entries for the same functional code and organization structure  
should be together.)

The program produces subtotal every time the functional code or organizational structured code changes (Fig. 9-16 & 9-17). A detailed subtotal is produced for each functional area (Fig.9-18) and a total for the entire unit (Fig. 9-19).

If the UR summary table is requested then the total manning as a function of UR is produced (Fig. 9-20).

In addition, a basic authorization deck is produced if it is requested.



FIELD MAINTENANCE SQUADRON					DESC.			FSC			GRADE			QTY		
FNO																
23000	FIELD MAINT SQ			AA				4010			MAJ			1		
23000	FIELD MAINT SQ			AA				4010			LTC			1		
23000	FIELD MAINT SQ			AA				70250			SSG			1		
23000	FIELD MAINT SQ			AA				42632			CMS			1		
23000	FIELD MAINT SQ			AA				70230			LTC			1		
														5		
23000	UNIT ADMIN			AU				7024			CPT			1		
23000	UNIT ADMIN			AU				70250			SSG			1		
23000	UNIT ADMIN			AU				70230			LTC			1		
23000	UNIT ADMIN			AU				10050			MSG			1		
														4		
23100	FACTORY			MKN				53135			MSG			1		
														1		
23400	AFB SPACE GROUND EQUIPMENT			MKN				42175			MSG			1		
23400	AFB SPACE GROUND EQUIPMENT			MKN				42375			MSG			1		
23400	AFB SPACE GROUND EQUIPMENT			MKN				42175			MSG			1		
23400	AFB SPACE GROUND EQUIPMENT			MKN				42355			MSG			1		
23400	AFB SPACE GROUND EQUIPMENT			MKN				42355			MSG			1		
23400	AFB SPACE GROUND EQUIPMENT			MKN				42355			MSG			1		
23400	AFB SPACE GROUND EQUIPMENT			MKN				42355			MSG			1		
														35		

Figure 9-17. Partial Manpower Output for Field Maintenance.



COL	0
LTC	1
WJ	1
CPT	1
LT	2
TOTAL	5
CIV	1
CMS	2
CMS	3
MSG	1
POB	5
TSG	2
SSG	9
SSG	48
SOT	20
SIC	22
SIC	15
TOTAL	259

Figure 9-18. Organizational Subtotal for Manpower Output.

SUMMARY OF NUCLE KING

COL	1
LTC	7
MAJ	4
CPT	14
LT	3
TOTAL	29

CIV	4
-----	---

CMS	8
SMS	14
MSG	6
MSG	53
TSG	104
SSG	27
SSG	172
SGT	206
21C	55
21C	245
TOTAL	350

Figure 9-19. Manpower Output - Unit Totals.

P.C.E. TABLE FOR THE F16 LOFT AT 2000 FT. U.P. PER ACFT PER MONTH FOR 1/2 OF AUG, 1.10 3 WTD AND 1.15 1 WTD.  
MIN FOR TWO LOS DEPL

\*\*\*\*\*WARNING: THIS TABLE IS VALID FOR THE ABOVE CONDITIONS ONLY.\*\*\*\*\*

2/C U.F.	OFFICER	CIVILIAN	INLISTED	TOTAL
23	29	4	875	928
23	29	4	887	925
32	29	4	895	928
36	29	4	904	937
46	29	4	914	947
48	29	4	923	962
50	29	4	950	983
55	29	4	973	1012
60	29	4	1016	1049

Figure 9-20. Manpower Output Utilization Rate Summary Table.

## X. REPORTS

Reiterating, during the operation of the Simulation Model the following reports are produced:

- Performance Summary Report
- Resource Status Report
- Mission Status Report
- In-Process Status Report
- Backorder Status Report
- Diagnostic Report

Further discussion of these reports follows.

A. Performance Summary Report (PSR) - The PSR is produced automatically at specified intervals by the REFREQ. PSRs are in two levels, Level I and II. Level I PSRs summarize run data of specified intervals. Level II PSRs summarize Level Is. Review of the PSR at the prescribed intervals during the simulation run will permit the user to evaluate the progress and values of the problem. Should the user find a value that appears improper or illogical he should stop the simulation and review the input data for validity. There are some misleading entries, however, as in the case of lines 26 and 27 of Fig. 10-1 having identical values. LCOM makes the assumption that manhour availability equals manhours authorized except in the case of flight crews in which Duty Not Involving Flying (DNIF) is addressed for crew ratio studies. While the PSR appears to be self-explanatory it does necessitate study in AFLC Report 70-1. For example, using Figure 10-1, refer to line 41, Most Troublesome Personnel Items. Disregard the column headings, then refer to the resource dictionary for first-digit identity. In this case, under the column which is entitled "CREWCH" the digits 2.01 appear and mean crew chiefs on the first shift were a problem. Note under column "COMSPL" the digits 5.01. Referring to the Resource Dictionary reveals that hydraulic technicians on the first shift were a problem area. Referring to line 82 under column "TRUCK" the digits 10.0, found as 10-Truck in the Resource Dictionary mean that a truck or trucks were problem areas. Note that no reference

PUM NUMBER LCON22		P E R F O R M A N C E S U M M A R Y					P E R I O D F R O M 4.0 TO 3.0				
		S H O P R E P A I R									
		TOTAL	PUMPH1	PUMPH2	BNASSY	RADC11	RADC12	RMS500	SMT8MS	MISSIS	
44	NO. OF REPAIRABLE GENERATIONS	161.0	1.0	2.0	40.0	31.0	33.0	24.0	15.0	0.0	
45	PCT BASE REPAIR	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	
46	PCT DEPOT REPAIR	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
47	AVERAGE BASE REPAIR CYCLE	0.15	1.55	1.41	0.17	0.00	0.07	0.0	0.0	0.0	
48	PCT ACTIVE REPAIR	100.0	100.0	100.0	100.0	100.0	100.0	0.0	0.0	0.0	
49	PCT WHITE SPACE	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
50	NO. OF ITEMS IN P-PAIR (EOP)	14.0	0.0	1.0	1.0	7.0	5.0	0.0	0.0	0.0	
51	NO. OF ITEMS RACKINGED (EOP)	50.0	0.0	0.0	5.0	0.0	0.0	24.0	15.0	0.0	
52	RESERVED -- NOT USED	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
53	RESERVED -- NOT USED	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
		S U P P L Y									
		TOTAL	PUMPH1	PUMPH2	BNASSY	RADC11	RADC12	RMS500	SMT8MS	MISSIS	
54	TOT DOLLAR INVEST.(1000)(EOP)	6784.0	0.30	0.30	3.0	1.50	1.50	400.0	400.0	1100.50	
55	FILL RATE PERCENT	82.12	100.0	100.0	30.77	32.25	42.42	100.0	100.0	100.0	
56	NUMBER OF RACKORDER-DAYS	10.71	0.0	0.0	3.44	4.34	2.00	0.0	0.0	0.0	
57	NUMBER OF UNITS DEMAND	392.0	1.0	2.0	40.0	31.0	33.0	192.0	60.0	24.0	
58	PCT OFF-THE-SHELF	82.12	100.0	100.0	30.77	32.25	42.42	100.0	100.0	100.0	
59	PCT EXPEDITED REPAIR	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
60	PCT PREEMPTION	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
61	PCT DEMANDS NOT SATIS.	17.85	0.0	0.0	61.22	67.72	57.56	0.0	0.0	0.0	
62	NUMBER OF CANNIBALIZATIONS	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
63	NO. ITEMS ON RACKORDER (EOP)	3.0	0.0	0.0	1.0	1.0	1.0	0.0	0.0	0.0	
64	RESERVED -- NOT USED	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
65	MOST TROUBLE-SOME SUPPLY ITEMS	0.0	11.0	12.0	13.0	14.0	15.0	16.0	17.0	18.0	
66	RESERVED -- NOT USED	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
67	RESERVED -- NOT USED	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
		F O U L P M F N T									
		TOTAL	TRUCK								
68	TOT DOLLAR INVEST.(1000)(EOP)	6.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
69	EQUIPMENT HOURS AVAIL. (100)	0.72	0.72	0.72	0.72	0.72	0.72	0.72	0.72	0.72	
70	EQUIPMENT HOURS AVAIL. (100)	0.72	0.72	0.72	0.72	0.72	0.72	0.72	0.72	0.72	
71	PCT USED -- UNSCHED MAINT	11.11	11.11	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
72	PCT USED -- SCHED MAINT	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
73	PCT UNUSED	88.87	88.87	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
74	NUMBER OF RACKORDER-DAYS	52.0	52.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
75	NUMBER OF UNITS DEMAND	84.59	84.59	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
76	PCT AVAILABLE	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
77	PCT PROV. BY EXPEDITE	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
78	PCT PROV. BY PREEMPTION	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
79	PCT DEMANDS NOT SATIS.	15.30	15.30	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
80	EQUIP. HOURS RACKINGED(EOP)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
81	RESERVED -- NOT USED	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
82	MOST TROUBLE-SOME EQUIP. ITEMS	0.0	10.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
83	RESERVED -- NOT USED	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
84	RESERVED -- NOT USED	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	

Figure 10-1. Expanded Performance Summary Report.

SUM NUMBER LCM22		P E R F O R M A N C E S U M M A R Y										P E R I O D F R O M 0.0 TO 3.0			
O P E R A T I O N S		TOTAL	RECON	INTRO1	CLSP11	CLSP12	INTRO2	INTRO3	FERRY						
1	NUMBER OF MISSIONS REQUESTED	39.0	21.0	6.0	3.0	3.0	3.0	3.0	0.0						
2	NUMBER ACCOMPLISHED	39.0	21.0	6.0	3.0	3.0	3.0	3.0	0.0						
3	PERCENT ACCOMPLISHED	100.0	100.0	100.0	100.0	100.0	100.0	100.0	0.0						
4	RESERVED -- NOT USED	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0						
5	RESERVED -- NOT USED	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0						
6	NUMBER OF SORTIES REQUESTED	75.0	30.0	12.0	12.0	12.0	6.0	3.0	0.0						
7	NUMBER ACCOMPLISHED	75.0	30.0	12.0	12.0	12.0	6.0	3.0	0.0						
8	PERCENT ACCOMPLISHED	100.0	100.0	100.0	100.0	100.0	100.0	100.0	0.0						
9	RESERVED -- NOT USED	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0						
10	RESERVED -- NOT USED	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0						
11	RESERVED -- NOT USED	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0						
12	RESERVED -- NOT USED	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0						
A I R C R A F T		TOTAL	F40												
13	NUMBER OF AIRCRAFT AUTH. (ENP)	10.0	0.0												
14	NUMBER OF AIRCRAFT-DAYS AVAIL.	54.0	0.0												
15	PCT SORTIES (INCL ALERT)	7.45	7.45												
16	PCT UNSCHED MAINTENANCE	12.34	12.34												
17	PCT SCHED MAINTENANCE	12.0	12.0												
18	PCT MWS	6.18	6.18												
19	PCT MISSION WAIT STATUS	0.0	0.0												
20	PCT SERVICE + MSW. WAIT	20.30	20.30												
21	PCT OPERATIONALLY READY	41.70	41.70												
22	AVG. AIRCRAFT TURNAROUND TIME	7.79	7.79												
23	AVG. NO. OF SORTIES/ A/C /DAY	1.30	1.30												
24	FLYING HOURS	96.50	96.50												
25	RESERVED -- NOT USED	0.0	0.0												
P E R S O N N E L		TOTAL	CREWCH	OMPEPS	FLTFMR	MYDTEC	MYDSPL	CONTEC	CONSPI	MUNSP1					
26	MANHOURS AUTHORIZED (100)	67.22	6.24	21.56	4.79	5.99	4.79	4.79	4.79	0.0					
27	MANHOURS AVAILABLE (100)	67.22	6.24	21.56	4.79	5.99	4.79	4.79	4.79	0.0					
28	PERCENT UTILIZATION	11.40	12.61	10.73	6.62	1.59	2.48	40.14	41.70	0.0					
29	MANHOURS USED (100)	7.04	0.79	2.37	0.32	0.18	0.12	2.31	2.00	0.0					
30	PCT UNSCHED. MAINTENANCE	61.07	0.0	3.33	100.0	100.0	100.0	100.0	100.0	0.0					
31	PCT SCHED. MAINTENANCE	30.11	100.0	96.49	0.0	0.0	0.0	0.0	0.0	0.0					
32	RESERVED -- NOT USED	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0					
33	NUMBER OF MFM DEMANDS	2022.0	311.0	424.0	64.0	20.0	71.0	352.0	450.0	372.0					
34	PCT AVAILABLE (PRIME)	93.31	94.19	100.0	100.0	100.0	100.0	93.16	92.70	83.04					
35	PCT AVAILABLE (SURST.)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0					
36	PCT PROV. BY EXPEDITE	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0					
37	PCT PROV. BY PREEMPTION	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0					
38	PCT DEMANDS NOT SATIS.	6.08	5.79	0.0	0.0	0.0	0.0	6.02	7.21	16.12					
39	OVERTIME MANHOURS USED (100)	0.05	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0					
40	MANHOURS PER FLYING HOUR	0.21	0.01	2.40	0.33	0.10	0.12	2.39	2.07	0.0					
41	MOST TROUBLESOME PERS. ITEMS	0.0	2.01	2.02	2.03	3.01	3.02	3.03	5.01	5.02					
42	RESERVED -- NOT USED	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0					
43	RESERVED -- NOT USED	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0					

Figure 10-1 (continued). Expanded Performance Summary Report

is made to the applicable shift. Additionally for any line entry with "100" or "1000" shown in parentheses, the corresponding data should be multiplied by that value. Where an "EOP" appears in parentheses the statistic represents status as of the end of the reporting period. It does not mean Engine Out of Commission for Parts! All other line entries represent statistics accumulated during the reporting period.

Some reports are interpreted in a special manner based upon the manner of computation. Examples follow:

1. Fill Rate Percentage - This statistic is computed by dividing the number of units available when initial demands occur by the total number of such demands. Only prime items (no substitutions) are considered, even though the demands may have been immediately satisfied by use of substitutes, preemption, etc. Only demands for new jobs are included; jobs coming off backorder or jobs restarting after being preempted are excluded.
2. Percent Off-the-Shelf - This statistic is computed on the basis of initial demands that are immediately satisfied by either prime or substitute items.
3. Number of Backorder Days - This is a time weighted statistic representing the summation of each unsatisfied demand (backorder) for an item multiplied by the number of days the unit for this demand was back-ordered. This summation represents only those backorders active or filled during the period of the report, including those backordered prior to this time period.
4. Most Troublesome Items - Listed here are the identifications of resource items causing the most trouble during the reporting period, reading from left to right. Those items should be ranked according to their Utilization Indices. For personal items, the number of the

decimal indicates the shift number. Whenever zeroes appear, there is no shift differentiation and shifts should be ignored. It should be noted that these statistics have significance only when the Decision Model is employed and they have no relationship to the column headings whatsoever. This information just utilizes the number of columns available.

B. Special Request Reports - When requested according to the instructions described in Chapter VIII, Section M2, AFLC 70-1, the following output reports may be obtained from the Simulation Model:

- Resource Status
- Mission Status
- In-Process Status
- Backorder Status
- Diagnostic

The first four of these reports contain data representing the status of the simulated environment at particular points in the simulated time period specified by the user when requesting the report. The last report (Diagnostic) is used by a programmer or experienced user of the model as an aid in locating suspected malfunctions of the model. In effect, this report lists data for each transaction that occurs between two points in simulation time, as specified on the request card.

C. Manpower Matrix - The input model has recently been modified to automatically print the Change Variables information in a more useable form. "SWICH" #12 now controls the outputting of data for the Manpower Matrix program at the option of the user. Example matrix outputs are shown in Figs. 2-4 to 2-8.

D. New Reports and Diagnostics - The Input Model Node Usage Report (Fig. 10-2) and the Main Model Q STAT Report (Fig. 10-3) comprise the new reports incorporated within the updated input models. Several new diagnostics have been added and the reader should refer to AFLC 74-1 for a complete list and discussion of all system diagnostic messages.



## E. Output Products

### 1. Input Model

a. AFLC recently updated the LCOM programs contractually. The major changes involving the input model are the Form 17 and Form 19 processing. With the Extended Form 17 processing, certain warning messages may appear, such as if the search pattern ATTRIT is redefined or if data are omitted from the Report Column or from the Initial or Post Sortie Class Columns. In the latter case, the first class listed (standard class) is always assumed. With the Form 19 processing, certain warning messages again may be listed. One message will always appear if the first Reconfiguration Entry Node within a search pattern is blank. In this situation, the model assumes no reconfiguration. As an aid in analyzing/reviewing reconfiguration networks and data, one additional diagnostic message and two new tables have been added. Message 52 will list all search patterns never referenced. The Search Pattern Table and the Class Table, taken together, will describe search pattern references and the frequency of classes searched.

b. The Node Usage Report (Fig. 10-2) is a valuable aid in debugging input data packages by listing any undefined or unused nodes and the form number and frequency with which the nodes are referenced. This report is produced automatically by the input model. However, in order to conserve paper and/or printing time on large data packages, a non-blank character in Col 52 of the System Specification Card (Honeywell Series 600/6000 computers) will result in only those undefined unused nodes being listed.

### 2. Main Model

a. Fig. 10-3 shows an example of the QSTAT Report. A QSTAT Report can be obtained via a change card with the "requested time value" entered in the FPAR field. This report provides, in a matrix format, the number of A/C in each class/configuration at user specified times during a

MS, 017 FORM 11 NODE USAGE REPORT									
NODE NAME	UNDESIGNED (SEE FOOTNOTES)	-----NODE USED AS SPECIFIED IN COLUMN STARTING FOR THE NUMBER OF TIMES INDICATED-----		NEXT NODES		ENTERED NODES		REMOVED NODES	
		ON FORM 11 (COL 1)	ON FORM 11 (COL 2)	ON FORM 11 (COL 3)	ON FORM 11 (COL 4)	ON FORM 11 (COL 5)	ON FORM 11 (COL 6)	ON FORM 11 (COL 7)	ON FORM 11 (COL 8)
A		1	0	0	1	0	0	0	0
A10		1	0	7	0	0	0	0	0
A1		1	0	0	1	0	0	0	0
C1		1	2	0	0	0	0	0	0
A11		1	1	0	0	0	0	0	0
C11		1	1	0	0	0	0	0	0
P		1	0	4	0	0	0	0	0
A1		2	1	0	0	0	0	0	0
A1A		1	1	0	0	0	0	0	0
A1B		1	1	1	0	0	0	0	0
A1B1		1	1	1	0	0	0	0	0
A1B2		1	1	1	0	0	0	0	0
E		3	4	0	0	0	0	0	0
F		1	1	0	0	0	0	0	0
B2		1	0	0	1	0	0	0	0
C2		1	2	0	0	0	0	0	0
C22		1	1	0	0	0	0	0	0
B2		2	1	0	0	0	0	0	0
B2A		1	1	0	0	0	0	0	0
B2B		1	1	1	0	0	0	0	0
B2B1		1	1	1	0	0	0	0	0
B2B2		1	1	1	0	0	0	0	0
B2B3		1	1	1	0	0	0	0	0
B2B4		1	1	1	0	0	0	0	0
B2B5		1	1	1	0	0	0	0	0
B2B6		1	1	1	0	0	0	0	0
B2B7		1	1	1	0	0	0	0	0
B2B8		1	1	1	0	0	0	0	0
B2B9		1	1	1	0	0	0	0	0
B2B10		1	1	1	0	0	0	0	0
B2B11		1	1	1	0	0	0	0	0
B2B12		1	1	1	0	0	0	0	0
B2B13		1	1	1	0	0	0	0	0
B2B14		1	1	1	0	0	0	0	0
B2B15		1	1	1	0	0	0	0	0
B2B16		1	1	1	0	0	0	0	0
B2B17		1	1	1	0	0	0	0	0
B2B18		1	1	1	0	0	0	0	0
B2B19		1	1	1	0	0	0	0	0
B2B20		1	1	1	0	0	0	0	0
B2B21		1	1	1	0	0	0	0	0
B2B22		1	1	1	0	0	0	0	0
B2B23		1	1	1	0	0	0	0	0
B2B24		1	1	1	0	0	0	0	0
B2B25		1	1	1	0	0	0	0	0
B2B26		1	1	1	0	0	0	0	0
B2B27		1	1	1	0	0	0	0	0
B2B28		1	1	1	0	0	0	0	0
B2B29		1	1	1	0	0	0	0	0
B2B30		1	1	1	0	0	0	0	0
B2B31		1	1	1	0	0	0	0	0
B2B32		1	1	1	0	0	0	0	0
B2B33		1	1	1	0	0	0	0	0
B2B34		1	1	1	0	0	0	0	0
B2B35		1	1	1	0	0	0	0	0
B2B36		1	1	1	0	0	0	0	0
B2B37		1	1	1	0	0	0	0	0
B2B38		1	1	1	0	0	0	0	0
B2B39		1	1	1	0	0	0	0	0
B2B40		1	1	1	0	0	0	0	0
B2B41		1	1	1	0	0	0	0	0
B2B42		1	1	1	0	0	0	0	0
B2B43		1	1	1	0	0	0	0	0
B2B44		1	1	1	0	0	0	0	0
B2B45		1	1	1	0	0	0	0	0
B2B46		1	1	1	0	0	0	0	0
B2B47		1	1	1	0	0	0	0	0
B2B48		1	1	1	0	0	0	0	0
B2B49		1	1	1	0	0	0	0	0
B2B50		1	1	1	0	0	0	0	0
B2B51		1	1	1	0	0	0	0	0
B2B52		1	1	1	0	0	0	0	0
B2B53		1	1	1	0	0	0	0	0
B2B54		1	1	1	0	0	0	0	0
B2B55		1	1	1	0	0	0	0	0
B2B56		1	1	1	0	0	0	0	0
B2B57		1	1	1	0	0	0	0	0
B2B58		1	1	1	0	0	0	0	0
B2B59		1	1	1	0	0	0	0	0
B2B60		1	1	1	0	0	0	0	0
B2B61		1	1	1	0	0	0	0	0
B2B62		1	1	1	0	0	0	0	0
B2B63		1	1	1	0	0	0	0	0
B2B64		1	1	1	0	0	0	0	0
B2B65		1	1	1	0	0	0	0	0
B2B66		1	1	1	0	0	0	0	0
B2B67		1	1	1	0	0	0	0	0
B2B68		1	1	1	0	0	0	0	0
B2B69		1	1	1	0	0	0	0	0
B2B70		1	1	1	0	0	0	0	0
B2B71		1	1	1	0	0	0	0	0
B2B72		1	1	1	0	0	0	0	0
B2B73		1	1	1	0	0	0	0	0
B2B74		1	1	1	0	0	0	0	0
B2B75		1	1	1	0	0	0	0	0
B2B76		1	1	1	0	0	0	0	0
B2B77		1	1	1	0	0	0	0	0
B2B78		1	1	1	0	0	0	0	0
B2B79		1	1	1	0	0	0	0	0
B2B80		1	1	1	0	0	0	0	0
B2B81		1	1	1	0	0	0	0	0
B2B82		1	1	1	0	0	0	0	0
B2B83		1	1	1	0	0	0	0	0
B2B84		1	1	1	0	0	0	0	0
B2B85		1	1	1	0	0	0	0	0
B2B86		1	1	1	0	0	0	0	0
B2B87		1	1	1	0	0	0	0	0
B2B88		1	1	1	0	0	0	0	0
B2B89		1	1	1	0	0	0	0	0
B2B90		1	1	1	0	0	0	0	0
B2B91		1	1	1	0	0	0	0	0
B2B92		1	1	1	0	0	0	0	0
B2B93		1	1	1	0	0	0	0	0
B2B94		1	1	1	0	0	0	0	0
B2B95		1	1	1	0	0	0	0	0
B2B96		1	1	1	0	0	0	0	0
B2B97		1	1	1	0	0	0	0	0
B2B98		1	1	1	0	0	0	0	0
B2B99		1	1	1	0	0	0	0	0
B2B100		1	1	1	0	0	0	0	0

Figure 10.2. Node Usage Report.

Figure 10.2 (continued). Node Usage Report.

simulation. Within each class, the total is broken down by A/C status (i.e., 'Ready', 'Cocked', 'Processing').

The columns of the matrix represent the class/configurations up to a total of 10. From left to right, the first column represents the first class defined on the Form 17 and the last column represents the last class defined on the Form 17 (if only 6 classes were defined, then column 6 represents the last class--columns 7-10 could be meaningless). If Form 19 is read before Form 17, then the first column would represent the first class searched, etc. However, in either case, the Input Model provides a listing of the class/configuration dictionary which shows the order and number of the classes. This number corresponds to the columns, beginning with class 1 (column 1) directly under the word "CLASSES."

Each row represents an A/C flag status. The first three rows represent the basic flag values of 'Ready' (Ø), 'Cocked' (20), and 'Processing' (20). Subsequent rows are an expanded look at the 'Processing' row. The total in each column of the subsequent rows will equal the values in row 3. Class and flag status totals are provided to the right as well as total-on-hand, total authorized, and the total number of A/C in Que (1), which are those A/C requests not yet satisfied.

Two additional points are important concerning the QSTAT report:

- (1) The first class (column 1) is the class the A/C are in at the beginning of the simulation. QSTATs during the first day of simulation are good for debugging and show what happens to the aircraft;
- (2) The most important use of the QSTAT report is to find errors in the Form 17's and 19's. A buildup in the Ready status of any class indicates that one or more of the search patterns need to be improved. If not, serious bottlenecks of aircraft availability will occur.

STATUS	ELAB	CLASSES	A/C	TYPE	CLASS	CONF	IG	STATUS	REPORT	TIME
READY	0	0	0	4	0	0	0	TOT.FIAC	4	2:7200
COCKED	20	0	0	0	0	0	0	TOT.FIAC	20	
PROCESSING	>0	0	5	2	0	0	0	TOT.FIAC >20	13	
								TOT.ALI A/C	5	
								OMND	5	
								AIYM	1A	
								TOTOT	0	

DETAIL REPORT OF IN-PROCESS FLAGS	
ELAB	CLASSES
PSP IND AC	40
PSP MIN AC	40
PSP MVV/SPARF	00
PSP VAL MSN	100
POST MSN PRC	200
FLYING	300
CKD NEW MSN	400

FIGURE 10.3 Q-STAT REPORT (AIRCRAFT QUEUE STATUS)

b. Resource Status - This report, shown in Fig. 10-4, gives the status of all resources defined by the user and some statistics on the amount of use. Most of the headings are self-explanatory since they represent standard abbreviations and are defined as follows:

- ID - identification number of the resource, used by the simulation program. (Reference dictionary from Input Model)
- RPCOL - the column of the summary report in which statistics are collected.
- TYPE - defined by user. (1-aircraft, 2-parts, 3-equipment, 4-facilities)
- SUB - substitute resource identification number.
- UCOST - unit cost of the resource, defined by user.
- AUTH - authorized quantity. This figure plus the cost should identify the particular resource to the user.
- OH - the number on hand, i.e., those serviceable items not in use.
- DIB - the due-in-balance, i.e., the number of items to be replaced in the start pool thereby increasing the stock level.
- DOB - the due-out-balance, i.e., those items for which a demand has been recorded but not yet filled.
- NDEM - the number of demands that have been made on the resource. If the Decision Model is being used, this will be the number of demands since the last decision report.
- CUTIL - an indication of the utilization of this resource since the last Decision report. A negative value indicates that there has been more waiting for this resource than there has been time that the spare resource was available.

# REFERENCES

- 1 - EAD
- 2 - EADSC
- 3 - EADSC
- 4 - EADSC
- 5 - EADSC
- 6 - EADSC
- 7 - EADSC
- 8 - EADSC
- 9 - EADSC
- 10 - EADSC
- 11 - EADSC
- 12 - EADSC
- 13 - EADSC
- 14 - EADSC
- 15 - EADSC
- 16 - EADSC
- 17 - EADSC
- 18 - EADSC
- 19 - EADSC
- 20 - EADSC

RESOURCES

HOLD NUMBER L-COM		RESOURCES										STIMULATION TIME = 2.55000	
10	RP COL	111	500	6000	7000	8000	9000	10000	11000	12000	13000	UTIL	LPST
1	1	1	0	9000	10	10	0	10	0	115	10.0444	0.	2.5220
2	1	3	0	8000	10	10	0	10	0	0	0.	1.	0.
3	2	3	0	7000	30	30	0	30	0	0	0.	2.	0.
4	3	3	0	7000	4	4	0	4	0	0	0.	7.	0.
5	4	3	0	7000	4	4	0	4	0	0	0.	3.	0.
6	5	3	0	6000	4	4	0	4	0	0	0.	4.	0.
7	6	3	0	7000	4	4	0	4	0	2	0.	5.	0.
8	7	3	0	6000	4	4	0	4	0	27	0.	6.	0.
9	1	4	0	1000	1	1	0	1	0	0	1.7280	0.	2.0494
10	1	4	0	1000	1	1	0	1	0	0	1.7069	0.	1.0226
11	4	4	0	1000	1	1	0	2	1	2	0.9813	0.	0.7560
12	5	4	0	1000	1	1	0	0	0	0	-0.8749	0.	2.2023
13	4	4	0	500	1	1	0	0	0	14	-5.3945	0.	2.2542
14	5	4	0	500	1	1	0	2	1	12	-0.8018	0.	2.2520

Figure 10-4 RESOURCES STATUS REPORT

HOLD NUMBER L-COM		RESOURCES										STIMULATION TIME = 2.12000	
10	RP COL	111	500	6000	7000	8000	9000	10000	11000	12000	13000	UTIL	LPST
1	1	1	0	9000	10	10	0	10	0	115	10.0444	0.	2.5220
2	1	3	0	8000	10	10	0	10	0	0	0.	1.	0.
3	2	3	0	7000	30	30	0	30	0	0	0.	2.	0.
4	3	3	0	7000	4	4	0	4	0	0	0.	7.	0.
5	4	3	0	7000	4	4	0	4	0	0	0.	3.	0.
6	5	3	0	6000	4	4	0	4	0	0	0.	4.	0.
7	6	3	0	7000	4	4	0	4	0	2	0.	5.	0.
8	7	3	0	6000	4	4	0	4	0	27	0.	6.	0.
9	1	4	0	1000	1	1	0	1	0	0	1.7280	0.	2.0494
10	1	4	0	1000	1	1	0	1	0	0	1.7069	0.	1.0226
11	4	4	0	1000	1	1	0	2	1	2	0.9813	0.	0.7560
12	5	4	0	1000	1	1	0	0	0	0	-0.8749	0.	2.2023
13	4	4	0	500	1	1	0	0	0	14	-5.3945	0.	2.2542
14	5	4	0	500	1	1	0	2	1	12	-0.8018	0.	2.2520

Figure 10-5 RESOURCES STATUS REPORT

UTIL - the utilization index used by the Decision Model.  
This is computed from CUTIL each decision period.

LPOST - the time that CUTIL was last incremented or decremented.

c. Mission Status - This report, shown in Fig. 10-5, provides the information on the missions which have been scheduled. The headings have the following meanings:

ID - the identification of the mission, used by the programs.

TYPE - mission type, defined by user.

PRI - the priority of the mission

MINAC - minimum aircraft which must be available for the mission before the cancel time.

MAXAC - the maximum number of aircraft that were started through the pre-sortie tasks.

T/O TIME - scheduled takeoff time.

DURAT - duration of the mission (in hours).

CANC - the allowable waiting time before cancellation of the mission (hours after T/O time).

ID - the internal reference identification numbers of those aircraft assigned to the mission.

TYPE - the I.D. of the aircraft (from resource dictionary).

STATUS - the status of each aircraft

0: doing presortie tasks

1: ready for the mission

10: flying the mission

99: still in maintenance after mission has started



3. In-Process, Backorder Status, Diagnostic - These reports, shown in Figs. 10-6 through 10-8 give information on all tasks in the system, both those being accomplished and those which are waiting to be accomplished. Those headings which are self-explanatory can be used to obtain information on the start time, stop time, and the resources required for each task. Information on the other headings can be found in the Programmers' Guide, as well as information on the Diagnostic Report.

PROCESS STATUS REPORT										TIME = 3.200000		-- REQUIRED RESOURCES --	
JOB NO	JOB NAME	INDEX	INM	PTM	TRN	TRN TO	TRN	TIME	JOB LENGTH	TRN COUNT	MSN FLAG	RES IN	QTY REQ.
40	1	0	20295	0	13	20311	0.64233	23.79687	23.15625	1	0		
40	1	0	20305	0	13	20365	0.65576	32.17197	31.53125	1	0		
40	2	0	20007	0	11	20205	0.75928	22.79687	22.03906	1	0		
40	2	0	20447	0	13	37501	0.92076	28.92187	28.	1	0		
43	2	0	20271	0	14	37561	0.93774	23.40875	22.53125	1	0		
40	2	0	37505	0	13	20281	0.94214	23.27394	23.33594	1	0		
43	2	0	20317	0	14	37533	1.52432	24.62500	23.10156	1	0		
40	2	0	38257	0	13	20429	1.53479	30.45312	28.80469	1	0		
40	2	0	20337	0	13	20221	1.87207	27.83594	25.96875	1	0		
40	2	0	38257	0	13	37431	2.61035	27.72656	25.11719	1	0		
40	2	0	38117	0	13	20217	2.70117	24.34375	21.64844	1	0		
40	2	0	38257	0	13	37557	2.72070	22.79219	20.92394	1	0		
40	2	0	38497	0	13	20215	2.73145	26.14062	25.41406	1	0		
47	2	0	38105	20399	1	37557	3.14336	3.22363	0.02999	1	0	12	-1
												7	1

Figure 10.6 13: PREPARE STATUS REPORT

RES 17 OF 1989



## XI. OPERATIONAL TEST AND EVALUATION APPLICATION

### A. Responsibilities

1. AFTEC - AFTEC is responsible for conducting an independent evaluation of the operational suitability of emerging weapon systems and assessment of the cost of ownership. A part of the evaluation of the operational suitability is the supportability analysis. A manpower evaluation is a component part of the supportability analysis and is performed by use of LCOM or the Expected Value Model (EVM).

AFTEC is responsible for assembly of maintenance test data from ASD (basically the comparability analysis), from LSET members, and from the technicians in the field. From these data, networks are created for LCOM subsequent simulation and analysis. The same data are used for the EVM.

2. AFSC-ASD - ASD, during IOT&E, is responsible for conducting a comparability analysis of the emerging weapon system for establishing a frequency of maintenance and maintenance tasks. That information is subsequently provided to AFTEC for use in networking for LCOM.

3. Joint Test Force - The joint test force is responsible for collection of maintenance data pertaining to crew size, task time, MDS, WUC, owning work center, performing work center, start time, stop time, action taken code, and how malfunction code. These data are made available to both ASD and to AFTEC.

4. Using Command - During FOT&E, the using command is responsible for conducting the LCOM simulation as stipulated in the test plan. AFTEC may be an observer.

B. Types of LCOM Problems with AFTEC Participation

1. IOT&E - AFTEC may joint forces with ASD in performing an LCOM simulation for a manpower assessment during IOT&E or may perform an independent LCOM simulation with data inputs from ASD, Joint Test Force, contractor, and MDCS.
2. FOT&E - During FOT&E, AFTEC may conduct surveillance over the using commands performance of an LCOM simulation or may conduct the simulation independently.

C. Chronological Procedures for Modeling Emerging Weapon Systems - Since the analyst has already consulted Chapter III, LCOM Planning and accomplished substantial research, the following chronological procedures are recommended:

1. Documentary Research - Review the ROC, PMD, ILSP, Concept of Operations, Concept of Maintenance and AFHRL-TR-74-97 series.
2. Scenario - Consult with the using command DCS/O and DCS/LG for the detailed scenario. (See Chapter IV and Appendix C)
3. System Definition - Identify the weapon system by MDS, role, mission profiles, UE of modeled system, subsystems and associated components, configurations possible, support equipment required, and manpower requirements.
4. Data Retrieval - R&M data should be obtained from the MDCS for comparable aircraft, subsystems and components. This acquisition should include:

- a. Unscheduled maintenance -- on and off equipment.
- b. Scheduled maintenance data.
- c. Removal for access data.

Additional discussion is contained in Chapter VII.

- 5. Comparability Analysis - Comparability analysis reveals the similarities between existing systems, their subsystems, and components and the emerging weapon system. Reference Chapter VII for additional information. This analysis requires collaboration with ASD engineering staff, contractors, the prime ALC and maintenance technicians from the using command and the LSET.
- 6. Reliability Analysis - The reliability analysis will identify the frequency of maintenance actions by WUC and establish the items to be networked.
- 7. Scenario - Consult with the using command DCS/O and DCS/LG for the detailed scenario. (See Chapter IV and Appendix C.)
- 8. Networking (Preliminary) - Prepare main aircraft servicing networks, scheduled and unscheduled maintenance networks using the Extended Form 11, MDCS data and engineering estimates. (See AFHRL-TR-79-97 (II) and applicable WUC manuals.)
- 9. Network Verification/Revision - Conduct TDY to test site, contractor facilities and using command to review system, hardware, scenario, maintenance concept and reliability-maintainability estimates. Revise this review as necessary.
- 10. Data Base Development - Develop LCOM data base, reference Chapter VII and Chapter IX.

11. LCOM Main Program and Post-Processor Programs - Conduct unconstrained run of the simulation program and post-processors.

12. Analysis - Conduct unconstrained validation, imposition of resource constraints, and sensitivity analysis.

13. Moody Manpower Program - Evaluate impact of variation of flying schedules, conduct a regression analysis and extrapolate peak manpower requirements.

14. LCOM Reiterations - Conduct required LCOM reiterations to incorporate the latest test data, hardware modifications, changes in scenario or maintenance concepts/procedures, flying schedules, sortie rates and lengths.

D. Manpower Assessment Using Expected Value Model (EVM) - While LCOM is a very effective simulation model in providing very detailed estimates of expected manpower, parts requirements, and utilization rates, it is scenario-dependent. Consequently a bridge is needed to determine point estimates for manpower for changing scenarios, MTBF, MTTR, maintenance task times, and crew size changes.

This need will be filled by a computer program that will compute the expected values for manpower requirements by extracting the data from LCOM input cards for a particular system. Thus the evolution of EVM.

1. General

a. Characteristics of EVM

- (1) EVM is a deterministic calculation and not a simulation model
- (2) Utilizes data input in Extended Form 11 format.
- (3) Advantages compared to LCOM:



- (a) Consumes less resources than LCOM
  - 1 Computer time is less
  - 2 Model preparation time is shorter
- (b) Adaptable to non-flying systems

(4) Limitations Compared to LCOM

- (a) Does not consider interactions between manpower and other resources (e.g., AGE, spares)
- (b) Considers only average manpower as opposed to peak demands. Peak demands may be considered, however, if failure rates and utilization rates are changed, although this will not give the same results as the probabilistic methods of the LCOM simulation.
- (c) Provides no information for decisions related to shift loading.

2. Data Base Requirements

- a. Same general approach is used as for LCOM (i.e., comparability, test data, operational data, etc.).
- b. Networks are constructed in the same fashion as with LCOM except AGE, spares, facilities, etc. are not necessary in the networks. The network construction basically needs:
  - (1) Frequency of maintenance actions
  - (2) Probabilities of certain tasks being performed
  - (3) Identification of the accomplished task
  - (4) Manhours to accomplish task

- (5) Crew size
- (6) Air Force specialty code (AFSC)

c. Basic input from operations scenario is the monthly utilization rate.

### 3. Steps in the EVM Process

- a. Step 1: Collect data required for networking
- b. Step 2: Construct networks in the Extended Form 11 format
- c. Step 3: Run the EVM Program
  - (1) Input, Extended Form 11 and utilization rate
  - (2) Collect output from the EVM in the form of total direct manhours per month by AFSC.
- d. Step 4: Convert the EVM output to the form required for input into the Moody Manpower Model.
- e. Step 5: Format other input required by the Moody Manpower Model
- f. Step 6: Exercise manpower model and analyze the results.

### 4. Outputs

- a. Expected maintenance manhours by:
  - (1) Three-digit work unit code
  - (2) Two-digit work unit code
  - (3) Accumulative manhours as traced through the network (two-digit code).
  - (4) Aggregate expected maintenance manhours for the entire system.

b. Expected maintenance manhours by type of maintenance actions:

- (1) Scheduled (phase - preflight)
- (2) Unscheduled
- (3) On equipment
- (4) Off equipment

c. Diagnostics are to be determined. The EVM is currently under development.

d. Sensitivity Analyses

- (1) Provide for varying utilization rates
- (2) Provide for varying mean time between failures
- (3) Provide for varying maintenance action rates
- (4) Provide for varying task times
- (5) Provide for varying crew sizes

5. Card Format Description - Generally the data in the LCOM contains the following information by card columns.

Col 5-10	First Node
12-17	Task Name
19-24	Next Node
26-27	Selection Node
28-32	Selection Parameters
34-38	Work Unit Code
39	Special Character
40-41	
46-47	Task Time
49-50	Dist Parameter (% of Mean)
51	Distribution Type
52-53	Crew Size
54-58	AFSC Required
60	Resource Number
61-65	Next Resource Task Requirement

These data will be used by EVM.

# 6. CARD FORMAT DESCRIPTION

Specifically, lines 1 and 2 are as follows:

Line 1	ALA00	A11A00	A1A01	22	11A00	21	02	291	Crew Size AFSC 1 431X1	1B-4
Line 2	ALA01	A11A00	A1A02	D	11A00	21				
First Node		Task Name	Next Node	Selection Mode	Selec- tion Para- meter	Work Unit Code	Special Charac- ters	Mean Task Time (2 hrs)	% of Mean Distribu- tion Type	Next Resource (1 B-4 stand)

Figure 11-1. EVM Card Format Description.

7. EXTENDED FORM 11 DATA				A10-A7D	
ALAA00	FLAA00	ALAA01	H	11A00	FWD FUSELAGE
ALAA01	ALAA00	ALAA02	F	22 11A00 21	
ALAA02	ALAA00	ALAA03	D	11A00 21	02 29L 1431X1 1B4
ALAA03	ALAA00	ALAA04	E	11 11A00 21	16 29L 2431X1 1B4
ALAA04	ALAA00	ALAA05	E	11 11A00 21	10 29L 2431X1 1B4
ALAA05	ALAA01	ALAA06	E	78 11A00 21	12 29L 2534X0 1B4
ALAA06	SHOP	ALAA07	D	11A00 21	
ALAA07	LI1AA0	ALAA08	H	11A00	FUSELAGE LESS PAN
ALAA08	LI1AA0	ALAA09	G	00286 11A00 23	
ALAA09	LI1AA0	ALAA10	E	80 11A00*23	24 29L 1534X0
ALAA10	LI1AA0	ALAA11	E	20 11A00*23	10 29L 1534X0
ALAA11	LI1AA0	ALAA12	D	11A00 21	
ALAA12	LI1AA0	ALAA13	H	11A00	FWD FUSELAGE PANELS
ALAA13	LI1AA0	ALAA14	G	00295 11A00 23	
ALAA14	LI1AA0	ALAA15	E	95 11A00*23	28 29L 2534X0
ALAA15	LI1AA0	ALAA16	E	5 11A00*23	10 29L 1534X0
ALAA16	LI1AA0	ALAA17	D	11A00 21	

Figure 11-2. Extended Form 11 Data.

8. Examples of Selected EVM Computations - The following computations pertain to the forward fuselage portion (Work Unit Code 11A00). For the purpose of this example, all MTBFs and task times are assumed to be in hours. However, for a general program they may be in sorties, hours, weeks, months, etc.

a. Steps

- (1) Task F11A00 will occur every 22 hours.
- (2) Task A11A00 is done in sequence and requires:  
2 hours  $\pm$  29%, and 1 431X1 man
- (3) Tasks R11A00, M11A00, or M11A01 follow next with probabilities (maintenance action rates) of .11, .11, and .78, respectively.  
  
Task R11A00 requires 16 hours  $\pm$  29%, and 2 431X1's.  
Task M11A00 requires 10 hours  $\pm$  29%, and 2 431X1's.  
Task M11A01 requires 12 hours  $\pm$  29%, and 2 534X0's.
- (4) Computing the expected value for the three-digit work unit code, the result is:

Let X = desired number flying hours

Let X = 200 hours

Then:

$$\frac{X}{22} ((2 \text{ hrs} \times 1 \text{ man}) + .11 (16 \text{ hrs} \times 2 \text{ man}) + .11 (10 \text{ hrs} \times 2 \text{ man}) + .78 (12 \text{ hrs} \times 2 \text{ man}))$$

$$\text{Expected manhours } \frac{X}{22} (26.44) = X (1.202) = 240.36 \text{ hrs.}$$

The next two sections (FWD fuselage less PN and FWD fuselage panels) must be considered simultaneously due to the "G" selection mode. That is, the "G" mode value for each task is a proportion of the total "G" mode value for all tasks emanating from the same node, in this case "Node 5A1400."

b. Steps

- (1) The total "G" mode value branching from node 5A1A00 is equal to  $386 + 295 = 681$ . Therefore, the proportion for task L11AA0 is  $\frac{386}{681} = .57$ . The proportion for task L11ADA is, therefore, .43.
- (2) Task W11AA0 occurs 80% of the time and requires 24 hours and 1 534X0.
- (3) Task N11AA0 occurs 20% of the time and requires 10 hours and 1 534X9.

Therefore, if branch L11AA0 is taken at the "G" mode the expected maintenance manhours for the FWD Fuselage Less PN is as follows:

(200 hour flying program)

$$\frac{X}{22} (.57) .80 (24 \times 1) + .20 (10 \times 1)) = \underline{109.82} \text{ hours.}$$

- (4) Task W11AOA occurs 95% of the time, given that branch L11AOA is taken, and requires 28 hours and 2 534X0's.
- (5) Task N11ADA occurs 5% of the time, given that branch L11ADA is taken, and requires 10 hours and 1 534X0.

Therefore, if branch L11ADA is taken the expected maintenance manhours for the FWD Fuselage Panels is as follows:

(200 hour flying program)

$$\frac{X}{22} (.43 (.95 (28 \times 2) + .05 (10 \times 1))) = \underline{209.91} \text{ hours}$$

Therefore, the total expected maintenance manhours for the FWD Fuselage networks, given a flying program of 200 hours, is equal to the summation of hours at this point, or:

$$240.36 + 109.91 = \underline{560.09} \text{ hours.}$$

APPENDIX A  
LCOM ASSISTANCE LIST

		<u>Phone</u>
AFPRM:	Lt. Col. Gerald Thompson OPR Pentagon	AV-225-7685
AFTEC:	Lt. Col. Richard A. Gunkel (C) Chief, Supportability Analysis (A)	AV-964-0346
AFLC:	Mr. William F. Drake (A) AFLC/XRS Bldg 266 Area A Wright Patterson AFB, Ohio Responsible for update of basic program and its publications.	AV-787-7765
AFSC/ASD:	Lt. Col. Donald C. Tetmeyer Bldg 126 Area B - ENECC Wright Patterson AFB, Ohio Responsible for LCOM on emerging systems	513-255-6531
	Mr. Wayne Jansen Computer Center ASD Bldg. Wright Patterson AFB, Ohio Responsible for CDC 6600 version of LCOM Programs	513-255-6408
TAC:	Mr. E. Frank Potter 4400 MESAT Chief of LCOM for TAC	AV-432-5001
	Major M. L. York Analysis Assistance	
	Major J.W. Wassall Systems and Programs	
	Major J.J. Muehlhof Studies	
	Mr. Richard Jones Lead LCOM Programmer	



APPENDIX B  
SYMBOLS AND ABBREVIATIONS

A	Available Work Days per Month
ATC	Action Taken Code
AFLC	Air Force Logistics Command
AFSC	Air Force Specialty Code
AGE	Aerospace Ground Equipment
AMS	Avionics Maintenance Squadron
AMMS	Airborne Missile Maintenance Squadron
ASD	Aeronautical Systems Division
B	Loading or Downloading
C	Network Call Section
D	Decrement Clock Failures
DMS	Drone Maintenance Squadron
ECM	Aircraft Configured with ECM Pods
EW	Electronic Warfare
f(W)	Frequency of Task Performance
FHPM	Flying Hours per Month
FMS	Field Maintenance Squadron
FOB	Forward Operating Base
G	Probability that the Failure of a Subsystem Resulted from the Failure of a Particular Component
How MAL	How Malfunction Code
HRL	Human Resources Laboratory
K	Bench Checked, Found Serviceable
LCO	Launch Control Officer
LCOM	Logistics Composite Model

## APPENDIX B (Cont'd)

M	On Aircraft Repair
MEA	Maintenance Engineering Analysis
MISEDS	Machine Independent Systems Effectiveness Data System
MOB	Main Operating Base
M(W)	Manpower Required to Efficiently Support the Mission at Workload Factor Level W.
MA <sub>R</sub>	Number of Maintenance Actions Performed Against WUC
MMS	Munitions Maintenance Squadron
MSBMA	Mean Sorties Between Maintenance Actions
MTBF	Mean Time Between Failures
n	Sample Size
N	Not Repairable This Station, Ship to Depot
OMS	Organizational Maintenance Squadron
P <sub>R</sub>	Probability of an R Action
P <sub>w</sub>	Probability of an R Action
QEC	Quick Engine Change
R	Remove and Replace Action
RCS	Recovery Control System
RECCE	Reconnaissance Sortie
RPV	Remotely Piloted Vehicle
S	Sample Standard Deviation
S <sup>2</sup>	Sample Variance
STC	System Test Console
t	Task Time
T(W)	Direct Labor Hours Expended per Month at Workload Factor

APPENDIX B (Cont'd)

<u>T(W)</u>	Mean of n Observations of T(W)
TAC	Tactical Air Command
TDS	Tactical Drone Squadron
TFS	Tactical Fighter Squadron
TFW	Tactical Fighter Wing
V	Verification Action
W	Workload Factor
WA	Bench Checked, Repair Deferred
WDC	When Discovered Code
WF	Repair Action, Follows WC
WUC	Work Unit Code
WRSK	War Reserves Spares Kit

APPENDIX C  
SCENARIO DEVELOPMENT CHECKLIST

The following checklist should be used as a guide when developing a scenario for use in a Logistics Composite Model (LCOM) simulation. Items should be added or deleted as appropriate for the particular aircraft and situation being modeled.

a. General requirements:

- (1) Organization level and unit equipage (UE) by aircraft type.
- (2) Manpower availability (manhours per month).
- (3) Percentage of available manhours which must be allowed for indirect work.
- (4) Standard manning for Chief of Maintenance overhead, and for any work centers which will not be simulated.

b. Facilities and deployment:

- (1) Number of locations and UE size at each location.
- (2) Resupply time.
- (3) Allocation of equipment, such as AGE at each location.
- (4) Extent of maintenance capability required at each location.
- (5) Shelters and facilities at each location.

c. Mission requirements:

Identify mission types. Specify the following mission requirements for each mission type, or for each leg of each mission involving enroute stops:

- (1) Percent of total sorties.
- (2) Aircraft type.
- (3) Initial configuration (e.g., numbers and type of external tanks, ECM pods, cameras, guns, missiles, bombs, cargo handling and passenger comfort equipment, etc.).

- c. (4) Probability of and quantity of load expended (e.g., tank jettison, air to air missile firing, etc.).
- (5) Ending configuration and disposition.
- (6) Substitution rules for using alternate configurations.
- (7) Mission priority.
- (8) Flight sizes (maximum, minimum) and policy on sympathetic ground abort).
- (9) Mean sortie length and variation.
- (10) Recovery or enroute point (if not returning to same base).
- (11) Probability and conditions of air refuel.
- (12) Proportion flown at night.
- (13) Weather limitations by mission type (e.g., for bomb delivery, air refuel, air engagement, etc.).
- (14) Length of delays that can be tolerated before mission cancellation (e.g., for weather, maintenance, etc.).
- (15) Extent of operation of mission peculiar equipment (e.g., TV monitor if mission calls for AGM 65).

d. Operations and Scheduling Policy:

- (1) Base weather minimums for launch and recovery.
- (2) Conditions for air abort (including sympathetic).
- (3) Policy for ground and/or airborne spare aircraft.
- (4) Desired percent of available aircraft which will be turned to fly again the same day if possible.
- (5) Requirements for massed launch within a restricted time frame.
- (6) Requirements for complimentary missions or mission legs within a restricted time frame.
- (7) Is the fragmentation order basically the same for the period of simulation?

e. Ground alert:

- (1) Number of aircraft on alert per UE and deployed location.
- (2) Which missions flown from alert, as identified in paragraph c above.
- (3) Frequency of alert missions, as identified in paragraph c.1 above.
- (4) Replacement policy (e.g., replacement when launched, or same aircraft return to alert).
- (5) Duration of alert cycle.
- (6) Disposition at end of alert cycle.
- (7) Aircraft acceptance and/or alert quick turn policy and procedures.
- (8) Policy for dedicating personnel and equipment to alert.

f. Functional check flights (FCF):

- (1) Conditions requiring FCF.
- (2) Limitations on FCF (e.g., daylight only).
- (3) FCF duration.

g. Maintenance concepts and organization:

- (1) Organization structure (e.g., per AFM 66-1).
- (2) AFSC structure (e.g., integrated avionics versus functional avionics specialties).
- (3) Quick turn conditions and procedures, including extent of deferred maintenance.
- (4) Remote versus home station maintenance, including criteria for deferred maintenance and team dispatch.
- (5) Policy for launch support.
- (6) Conditions requiring down load.

- (7) Repair level concept by subsystem.
- (8) Phase inspection interval; corrosion control, gun inspections.

h. Combat damage:

- (1) Identify the threat to be used in estimating attrition and battle damage.
- (2) Extent of ram team and/or reserve augmentation for combat damage repair.
- (3) Policy for allocating combat damage repair to base, ram team, or depot.

i. Crew ratio study assumptions:

- (1) Identify by mission type:
  - (a) The time before scheduled takeoff that briefing should begin.
  - (b) The time after landing when debriefing will be completed.
  - (c) Any reduction in briefing/debriefing time when missions are flown in succession.
- (2) Describe aircrew scheduling rules:
  - (a) Formed crews.
  - (b) Multiple aircraft qualification.
  - (c) Flight lead or special qualification.
  - (d) Squadron integrity.
  - (e) Additional duty requirements (arrange hours per day per crew member).
  - (f) Maximum flight duty period.
  - (g) Minimum crew rest periods.
  - (h) Days off policy.

APPENDIX D  
LCOM CHECKLIST

1. Develop Plan
2. Get maintenance data.
3. Sort maintenance data.
4. Become familiar with the aircraft.
5. Produce a rough outline of the networks.
6. Analyze maintenance data.
7. Develop unscheduled maintenance networks.
8. Develop scheduled maintenance networks.
9. Develop scenarios.
10. Obtain cost data.
11. Obtain work unit code and manning data.
12. Identify failure clocks.
  - (a) Identify MSBMA
  - (b) Identify decrementing tasks.
13. Code Extended Form 11
14. Key punch and verify Extended Form 11
15. Create updatable data base (DBASE)
16. Check data base listing.
17. Run PHASE I part 1 (P1).
18. Check diagnostics
  - (a) Correct errors
  - (b) Rerun P1
19. Run PHASE I part 1 (P1), Part 2 (P2) and auxiliary programs (AUX)
  - (a) Save LCOM data base (FDATA)
  - (b) Get LCOM Forms 10, 13 and 16 from AUX
20. Prepare FDATA
  - (a) MODIFY
    - (1) LCOM Forms 11
    - (2) LCOM Forms 14
  - (b) Add
    - (1) LCOM Forms 10
    - (2) LCOM Forms 13
    - (3) LCOM Forms 16
    - (4) LCOM Forms 17
    - (5) LCOM Forms 13
    - (6) LCOM Forms 19
    - (7) 999999 end card



21. Run ZAP
22. Check diagnostics
  - (a) correct errors
  - (b) rerun ZAP
23. Code scenario
  - (a) LCOM Forms 20
  - (b) LCOM Forms 15
24. Run input model
25. Run simulation model
26. Set constraints
27. Rerun with constraints
28. Produce manpower matrix
29. Analyze manpower matrix
30. Analyze performance summary reports
31. Study costs
32. Write report

# APPENDIX E

## DATA ELEMENT

	COST OF OWNERSHIP					POTENTIAL SOURCE
	COMMON AGE (C22)	REPAIRS (C20)	REPAIRS (C21)	REPAIRS (C23)	REPAIRS (C24)	
Mean time between failure for all LRU's & SKU's.	X	X	X	X	X	
Mean time between maintenance action for all LRU's.	X	X	X	X	X	
Mean time between part removal for all LRU's.	X	X	X	X	X	
AFSC(S), crew size, and mean manhours required in place on the complete system for preparation for the LRU.	X	X	X	X	X	
AFSC(S), crew size, and mean manhours required for corrective maintenance of the LRU in place or on line including fault isolation, repair, and verification.	X	X	X	X	X	
AFSC(S), crew size, and mean manhours required for scheduled periodic or phased inspection on the system.	X	X	X	X	X	
AFSC(S), crew size, and mean manhours required to perform a shop bench check, screening, and fault verification on a removed subsystem prior to initiating repair action or condemning.	X	X	X	X	X	
AFSC(S), crew size, and mean manhours to perform intermediate maintenance on removed LRU.	X	X	X	X	X	
AFSC(S), crew size and mean manhours required to remove and replace a whole engine including trim and runup.	X	X	X	X	X	
(Combined engine maintenance removal time.	X	X	X	X	X	
Fraction of LRU's condemned.	X	X	X	X	X	
Fraction of LRU failures repaired in place or on line.	X	X	X	X	X	
Fraction of removed LRU's expected to be repaired at base.	X	X	X	X	X	
Bench check serviceable rate.	X	X	X	X	X	

DATA ELEMENT	COST OF OWNERSHIP						POTENTIAL SOURCE
	LCM	MCSF MODEL	MAINTENANCE MANPOWER (G5)	AVIATION POL (G6)	MAINTENANCE MATERIAL (G7)	REPLENISHMENT SPARES (G20)	COMMON AGE (G22)
Available work time per man in the base shop in manhours per month.						X	
Total cost of peculiar flight-line support equipment and additional items of common flight-line support equipment per base required for the system.						X	
Total cost of peculiar base shop support equipment per base required for the system which is not directly related to repair of specific LRUs or when the quantity required is independent of the anticipated workload such as overhead cranes and shop fixtures.						X	
Identification of redundant subsystems which are operate	X						
Identification of redundant subsystems which are standby	X						
Total number of subsystems by number and name.	X						
Number of mission phases	X						
Operating time of each subsystem during each mission phase	X						
Conditional probability of mission abort given a particular subsystem failure during each mission phase	X						
Phase through which MCSF is to be calculated.	X						
Number of years to be considered in calculating logistics support cost.	X						
Average number of missions per month per system.	X						

DATA ELEMENT	COST OF OWNERSHIP						POTENTIAL SOURCE
	LCOM	WSP MODEL	MAINTENANCE MANPOWER (G5)	AVIATION POL (G2)	MAINTENANCE MATERIAL (G2)	REPLACEMENT SPARES (G20)	COMMON AGE (G22)
Unit cost of spares.							
Supply recycle time for spares repaired on base.							
Supply recycle time for spares required at depot.							
Number of systems per squadron.							
Warfare utilization rate.							
Maintenance hours per flying hour.							
Multiplier factor to allow for AGE.							
Multiplier factor to allow for supervision.							
Productive direct labor hours.							
Annual flying hours per UE.							
Fuel Cost.							
Total number of UE							
Number of operating base locations.							
Total cost of additional items of common base.							
shop support equipment per base required for the system							

DATA ELEMENT	COST OF OWNERSHIP						POTENTIAL SOURCE
	LCM	MCSP MODEL	MAINTENANCE MATERIAL (G5)	AVIATION POL (G6)	MAINTENANCE MATERIAL (G7)	REPLENISHMENT SPARES (G20)	COMMON AGE (G22)
Fraction of removed LRU's expected to be returned to depot for repair.	X					X	
Quantity of like LRU's within the parent system.		X		X	X	X	X
Ratio of operating hours to flying hours for the LRU.					X		X
Cost of Maintenance Material per UE per year.				X			
Fuel consumption rate.			X				
Flying hour interval between scheduled periodic or phased inspection on the system.	X						
Number of engines per aircraft.		X					
Support equipment required to repair LRU.	X					X	
Annual cost to operate and maintain a unit of common support equipment or peculiar support equipment which is not directly workload related, expressed as a fraction of the unit cost.	X					X	
Combined utilization rate for all like items of support equipment at base level.	X					X	
Cost per unit of peculiar support equipment for the base shop.						X	
Annual cost to operate and maintain a unit of support equipment at base level.						X	
Fraction of downtime for a unit of support equipment for maintenance and calibration requirements.						X	
Base consumable material consumption rate in \$/monthour.				X			
Supply items required to repair LRU.	X						
Spares stock level.	X						

DATA ELEMENT	COST OF OWNERSHIP							POTENTIAL SOURCE
	MANPOWER (22)	AVIATION (22)	MAINTENANCE (22)	REPAIRS (22)	REPLACEMENT (22)	SPARE PARTS (22)	OTHER (22)	
Ratio of total operating time to mission operating time of each subsystem.								
Number of nonredundant options for each subsystem.								
Number of redundant options for each subsystem.								
Number of redundant units for each operative redundancy option for each subsystem.								
Number of redundant units for each standby redundancy option for each subsystem.								
MTBF, unit acquisition cost, and average cost per repair of each nonredundant option for each subsystem.								
MTBF, units acquisition cost, and average cost per repair of each redundant subsystem and redundancy option for each subsystem.								

APPENDIX F  
LCOM ACTION CODES FOR TASK PROCESSING

- A - Obtain and set up powered AGE.
- B - Loading or downloading.
- C - Network call section.
- D - Decrement failure clocks.
- F - Failure clock.
- G - Fueling or defueling.
- H - Inspections, service, scheduled checks.
- J - Aircraft handling and moving.
- K - In-shop bench check of LRU, find it serviceable.
- L - Dummy task for probabilistic determination of which LRU was removed from a failed subsystem.
- M - On-aircraft repair not involving LRU removal.
- N - In-shop bench check of LRU, find it broken determine repair can not be made at base level, prepare for shipment and order replacement from depot.
- P - Dummy task representing time to obtain replacement LRU from depot.
- Q - Draw LRU from base level stock.
- R - On-aircraft remove replace of an LRU.
- S - Dummy task representing shop entry point.
- T - On-aircraft troubleshoot.
- V - Inspect or functional check to verify on-aircraft repair.
- W - In-shop, bench check and repair LRU.
- X - On-aircraft gain access to subsystem and/or LRU.
- Z - Fly sortie.

# APPENDIX G

## WORK CENTER DESIGNATIONS

<u>SQUADRON</u>	<u>WORK CENTER</u>	<u>DESIGNATION (AFSC)</u>
OMS	Flight Line Maintenance	431X1F
	Periodic (Phase) Maintenance	431X1P
AMS	Airborne Computers	304X5
	Fire Control	322X1
	Auto-pilot	325X0
	Instruments	325X1
	Integrated Avionics Systems	326X2
	Radio	328X0
	Radar	328X1
	Doppler	328X4
	Drone Launch and Control	328X4M
FMS	Propeller	421X1
	Pneudraulics	421X2
	Aerospace Ground Equipment	421X3
	Environmental Systems	422X1
	Egress Shop	422X2
	Electrical Systems	423X0
	Fuel Systems	424X0
	Repair and Reclamation	431X1C
	Wheel and Tire	431X1D
	Jet Engines	432X0
	Machine Shop	531X0
	Metal Processing	532X0
	Structural Repair	534X0
MMS	Missile Systems Buildup	316X0
	Weapons Release Systems	322X1
	Weapon Buildup and Delivery	461X0
	Load Crews	462X0
	Gun Shop	462X0



APPENDIX H  
WORK UNIT CODE STRUCTURE  
EQUIPMENT CLASSES

<u>WUC</u>	<u>EQUIPMENT CLASS</u>
11XXX	Airframe
12XXX	Cockpit and Fuselage Compartments
13XXX	Landing Gear
14XXX	Flight Control
16XXX	Escape Capsule Crew Module
22XXX	Turbo Prop Power Plant
23XXX	Turbo Jet Power Plant
32XXX	Hydraulic Propellar
41XXX	Air Conditioning, Pressurization, and Surface Ice Control
42XXX	Electrical Power Supply
44XXX	Lighting System
45XXX	Hydraulic and Pneumatic Power Supply
46XXX	Fuel System
47XXX	Oxygen System
49XXX	Miscellaneous Utilities
51XXX	Instruments
52XXX	Autopilot
53XXX	Drone Airborne Launch and Guidance Systems
55XXX	Malfunction Analysis and Recording Equipment
61XXX	HF Communications
63XXX	UHF Communications
64XXX	Interphone
65XXX	IFF
66XXX	Emergency Communications
69XXX	Miscellaneous Communications Equipment
71XXX	Radio Navigation
72XXX	Radar Navigation
73XXX	Navigation Equipment, Inertial. Radar, Attack Radar, Terrain Following Radar, Doppler
74XXX	Fire Control
75XXX	Guns Weapons Control System
76XXX	Electronic Countermeasure
91XXX	Emergency Equipment
96XXX	Personal and Miscellaneous Equipment
97XXX	Explosive Devices and Components

APPENDIX I

# AIRMAN CLASSIFICATION STRUCTURE

(To be used in conjunction with AFM 39-1)

<u>SUPERINTENDENT LEVEL</u>	
36194	Outside Wire Installation and Maintenance Superintendent
36390	Inside Plant Maintenance Supt
39190	Maintenance Analysis Supt
40191	Office Machine Maintenance Supt
40390	Biomedical Equipment Maint Supt
40491	Photo Systems Maintenance Supt
42193	Aircraft Accessory Sys Supt
42292	Environmental and Egress Systems Superintendent
42390	Aircraft Electrical Supt
42491	Aircraft Fuel Systems Supt
43191	Aircraft Maintenance Supt
43291	Aircraft Engine Superintendent
43390	Maint Scheduling Superintendent

<u>LIST OF AUTHORIZED PREFIXES</u>	
<u>PREFIX</u>	<u>TITLE</u>
A	Aircrew
D	Automated Systems Programming Technician
E	Development Technician
G	C-5
H	Missile Combat Crew
L	Area Specialist
P	Parachutist
S	Logistics Planner
T	Technical Training Instructor
U	F/RF/FB-111 Personnel
W	Automated Systems Analyst

<u>SPECIAL DUTY IDENTIFIERS</u>	
<u>IDENTIFIER</u>	<u>TITLE</u>
99120	Recruiter
99127	Engineering or Scientific Assistant
99128	Military Training Instructor
99129	United States Air Force Honor Guard
99130	LGM-30 Facility Manager
99131	Courier
99134	Combat Information Monitor
99135	Combat Security Policeman
99136	Scatter Communications Maintenance Technician
99137	Data Formatting Equipment Operator
99138	Student Training Advisor
99139	ICBM Maintenance Manager
99140	Sensor Operator

<u>INPUT OR UNSKILLED LEVEL</u>	<u>SEMI-SKILLED LEVEL</u>
11010 Aircrew Operations Helper	11130 Apr Defensive Aerial Gunner 11230 Apr In-Flight Refueling Operator 11330 Apr Flight Engineer Specialist A Turboprop C Performance Qualified 11430 Apr Aircraft Loadmaster 11530 Apr Pararescue/Recovery Specialist
20010 Intelligence Trainee	20230 Apr Radio Comm Analysis Specialist 20330 Apr Linguist/Interrogator Spec 20331 Voice Processing Specialist 20430 Apr Intelligence Operations Spec 20530 Apr Electronic Intelligence Sp Sp 20630 Apr Imagery Interpreter Specialist 20731 Apr Morse Systems Operator 20732 Apr Printer Systems Operator
22010 Photomapping Helper	22130 Apr Photo Cartographic Specialist 22230 Apr Geodetic Surveyor 22231 Apr Geodetic Computations Spec
23010 Audiovisual Helper	23130 Apr Audiovisual Media Specialist A Editor B Sound 23131 Apr Graphics Specialist A Medical Illustrator 23132 Apr Still Photographic Specialist 23230 Apr Camera-Recording Specialist A Medical B Optical Instrumentation 23231 Television Production Specialist 23330 Apr Continuous Photoprocessing Sp 23331 Photoprocessing Control Specialist
INPUT FROM ANY 5-SKILL LEVEL AFSC IN ANY CAREER FIELD	24130 Apr Safety Specialist A Traffic Safety Assistant B Missile 24230 Apr Disaster Preparedness Spec
25010 Weather Trainee	25130 Apr Weather Specialist 25231 Apr Weather Observer
27010 Aerospace Operations Control Helper	27130 Apr Air Operations Specialist 27230 Apr Air Traffic Control Operator A Conventional Control Tower, Approach Control Tower B Ground Controlled Approach, Precision Approach Radar, Radar Approach Control C Air Route Traffic Control Center Manual, Air Route Traffic Control Center Radar, Air Traffic Regulation Center D Combat Control Team Operations 27430 Apr Command & Control Specialist 27530 Apr Aerospace Control & Warning Systems Operator 27631 Electronic Warfare Countermeasures Specialist 27632 Intercept Director Specialist

COMMUNICATIONS OPERATIONS 29	29010 Communications Operations Helper	29130 Apr Telecommunications Operations Specialist 29333 Apr Radio Operator A Airborne Command Post Comm 29430 Automatic Digital Switching Spec 29630 Communications-Electronics Pro-grams Management Specialist 29730 Radio Frequency Management Spec
COMMUNICATIONS- ELECTRONICS SYSTEMS 30	30010 Comm-Electronics Systems Helper	30230 Apr Weather Equipment Specialist 30231 Apr Abn Meteorological/Atmospheric Research Equipment Repairman 30331 Apr Air Traffic Con Radar Repair 30332 Apr AEW Radar Repairman 30333 Apr Auto Tracking Radar Repairman 30430 Apr Radio Relay Equipment Techn 30431 Apr Flight Facilities Eqp Techn 30434 Apr Ground Radio Comm Eqp Techn 30435 Apr Television Eqp Repairman 30436 Apr Space Comm Sys Eqp Opr/Specl 30534 Apr Electronic Computer Systems Specialist 30630 Apr Electronic Comm & Crypto Eqp Systems Repairman 30631 Apr Electronic-Mechanical Comm & Crypto Eqp Sys Repairman 30730 Apr Tele-Comm Sys Con Attendant 30830 Space Sys Cond & Con Eqp Opr/Specl 30930 Apr Missile Warning & Space Sur-veillance Sensor Repairman A Missile Detection & Warning Radar B Space Surveillance Radar
MISSILE ELECTRONIC MAINTENANCE 31	31010 Missile Electronic Helper	31630 Apr Missile Sys Analyst Specialist F LGM-25 G WS-133A, JS-133A/M H WS-133B Q AGM-28A/B S AGM-20 T AGM-69A 31631 Apr Missile Systems Maint Spec F LGM-25 L AIM-4/7/9, AGM-45, AGM-46, Laser Electro-Optical Weapons Eqs P RPV/Drone Q AGM-28A/B 31632 Apr Missile Eleet Eqp Specialist F LGM-25 G WS-133A, JS-133A/M H WS-133B J CIM/CQM Q AGM-28A/B T AGM-69A 31730 Apr Instrumentation Mechanic

	32010 Avionics Systems Helper	32130 Apr Bomb-Nav Systems Mechanic K B-52D/F/G/H/I: ASQ-4, ASQ-38 Sys; L B-52D/DH: ASB-15 System; 32131 Apr Defensive FCS Mechanic E B-52H: ASG-21 Turbine; J B-52D/F/G/H/I: ASG-16 Turrets; 32231 Apr Weapon Con Systems Mechanic A F-106A/B: MA-1, ASG-25 Systems; C F-106A/B: MA-1, ASG-25 Displays; F F-101B, F-105, F-102As, AG-10, MG-10 Systems H F-105: F-105-17 System P F-4U: AMO-400-1A Q F-4U: AMO-400 S A-10: AMO-400-10; A-10: AMO-400- 100, AMO-400-2, Laser Warper 32430 Apr Bomb Measuring Equip Specialist 32530 Apr Automatic Pilot Con Sys Spec 32531 Apr Avionics Instrument Sys Spec 32630 Apr Avionics Aerospace Control Sys Specialist 32631 Apr Integrated Avionics Component Specialist A Navigation/Flight & Weapon Con- trol B Communication/Mission & Traffic Control & Penetration Alts 32632 Apr Integrated Avionic Sys Spec A Inertial Bomb Navigation, Fire/ Weapons Control, Digital Com- puters, and Multi-sensor Dis- plays B Flight Control and Integrated Mechanical Instrumentation C Communications, Navigation, and RPM Systems 32930 Apr Avionic Communications Spec  32831 Apr Avionics Navigation Sys Spec 32832 Apr Air Early Warning Radar Spec 32833 Apr Electronic Warfare Sys Spec 32834 Apr Avionic Inertial & Radar Nav Systems Specialist 32930 Apr Avionic Sensor Systems Spec A Electronic Sensors B Electro-Optical Sensors
AVIONICS SYSTEMS 32		
	34010 Training Devices Helper	34131 Apr Instrument Trainer Specialist 34132 Apr Defensive Sys Trainer Spec 34230 Apr Flight Simulator Specialist 34330 Apr Nav Bomb Tactics Trainer Spec 34530 Apr Missile Trainer Specialist
TRAINING DEVICES 34		

WIRE COMMUNICATIONS SYSTEMS MAINTENANCE 36	36010 Wire Maintenance Helper	36130 Apr Outside Wire & Antenna Maintenance Repairman 36133 Apr Msl Sys Cable Maintenance/Splicing Specialist 36134 Apr Cable Maintenance/Splicing Specialist 36231 Apr Telephone Switching Eqp Repairman, Electro/Mechanical 36232 Apr Elect Switching Systems Repairman 36233 Apr Msl Con Comm Systems Repairman 36234 Apr Tel Equipment Installer-Specialist 36330 Apr Comm & Relay Center Eqp Repairman, Electro/Mechanical
MAINTENANCE ANALYSIS 39	39010 Maintenance Analysis Helper	39130 Apr Maintenance Analysis Specialist A Aerospace Weapon System B Communication-Electronic C Motor Vehicle
INTRICATE EQUIPMENT MAINTENANCE 40	40010 Intricate Eqp Maintenance Helper	40130 Apr Office Machine Repairman 40131 Tabulating Equipment Repairman 40330 Apr Biomedical Eqp Maint Specialist 40430 Apr Press Photo Systems Specialist 40431 Apr Aerospace Photo Sys Repairman
AIRCRAFT ACCESSORY MAINTENANCE 42	42010 Aircraft Accessories Maint Helper	42131 Apr Aaft Propeller Repairman 42132 Apr Aaft Pseudraulic Repairman 42133 Apr Aerospace and Eqp Repairman 42231 Apr Aircraft Environmental Systems Repairman 42232 Apr Aircraft Express Sys Repairman 42330 Apr Aaft Electrical Repairman 42430 Apr Aaft Fuel Systems Mechanic 42431 Apr In-Flight Refueling Sys Repairman
AIRCRAFT MAINTENANCE 43	43010 Aircraft Maintenance Helper	43130 Apr Helicopter Mechanic B Semiaarticulated Rotor (HH-43) C Fully Articulated Rotor (HH-43, HH-53, HH-53B) D Semirigid Rotor (HH-13, F-13, H-13) 43131 Apr Aircraft Maintenance Specialist A Reciprocating Engine Aircraft C Jet Aircraft One & Two Engine E Jet Aircraft Over Two Engine F Turbo-Prop Aircraft 43230 Apr Jet Engine Mechanic 43231 Apr Reciprocating Engine Mechanic 43330 Maint Scheduling Specialist

MISSILE MAINTENANCE 44	44010 Missile Maintenance Helper	44230 Apr Missile Pseudraulic Repairman 44330 Apr Missile Mechanic E LOM-25 G WS-133A, WS-133A/M, WS-133B J CIM-10 44331 Apr Missile Engine Mechanic
MUNITIONS AND WEAPONS MAINTENANCE 46	46010 Munitions & Weapons Maint Helper	46130 Apr Munitions Maint Specialist 46230 Apr Weapons Mechanic 46330 Apr Nuclear Weapons Specialist 46430 Apr Munitions Disposal Specialist
VEHICLE MAINTENANCE 47	47010 Vehicle Maintenance Helper	47230 Apr Base Vehicle Eqp Mechanic 47331 Apr Special Vehicle Mechanic A Firetrucks B Refueling Vehicles C Materials Handling Equipment D Towing and Servicing Vehicles 47332 Apr General Purpose Vehicle Mech 47333 Apr Vehicle Body Mechanic
COMPUTER SYSTEMS 51	51010 Computer Systems Helper	51130 Apr Computer Operator A Burroughs Systems B Honeywell Systems C IBM Systems 51131 Apr Programming Specialist A Burroughs Systems B Honeywell Systems C IBM Systems 51132 Computer Systems Analysis and Design Specialist



MUNITIONS AND WEAPONS MAINTENANCE 46	46010 Munitions & Weapons Maint Helper	46130 Apr Munitions Maint Specialist 46230 Apr Weapons Mechanic 46330 Apr Nuclear Weapons Specialist 46430 Apr Munitions Disposal Specialist
VEHICLE MAINTENANCE 47	47010 Vehicle Maintenance Helper	47230 Apr Base Vehicle Eqp Mechanic 47231 Apr Special Vehicle Mechanic A Firetrucks B Refueling Vehicles C Materials Handling Equipment D Towing and Servicing Vehicles 47232 Apr General Purpose Vehicle Mech 47233 Apr Vehicle Body Mechanic
COMPUTER SYSTEMS 51	51010 Computer Systems Helper	51130 Apr Computer Operator A Burroughs Systems B Honeywell Systems C IBM Systems 51131 Apr Programming Specialist A Burroughs Systems B Honeywell Systems C IBM Systems 51132 Computer Systems Analysis and Design Specialist
METALWORKING 53	53010 Metalworking Helper	53130 Apr Machinist 53131 Apr Metals Processing Specialist 53132 Apr Sheet Metal Specialist 53133 Apr Airframe Repair Specialist 53134 Apr Corrosion Control Specialist 53135 Apr Nondestructive Insp Specialist
MECHANICAL/ ELECTRICAL 54	54010 Mechanical-Electrical Helper	54130 Apr Missile Facilities Specialist F LGM-25 G WS-133A, WS-133B, WS-133A/M J CIM-10A/B 54230 Apr Electrician F LGM-25 54231 Apr Electric Power Line Specialist 54330 Apr Electrical Power Pdn Spec 54430 Apr Cryogenic Fluids Pdn Spec 54530 Apr Refrigeration & Air Condition- ing Specialist 54630 Apr Liquid Fuel Sys Maint Spec F LGM-25 54730 Apr Heating Systems Specialist A Plant Operator 54830 Nuclear Reactor Sys Specialist
STRUCTURAL/ PAVEMENTS 55	55010 Structural & Pavements Helper	55130 Apr Pavements Maintenance Spec 55131 Apr Construction Eqp Operator 55230 Apr Carpenter 55233 Apr Mason 55234 Apr Protective Coater 55235 Apr Plumber 55330 Apr Site Developer 55430 Apr Real Estate-Cost-Management Analysis Specialist 55530 Programs & Work Con Specialist

SANITATION 56	56010 Sanitation Helper	56630 Apr Entomologist 56631 Apr Environmental Support Spec
FIRE PROTECTION 57	57010 Fire Protection Helper	57130 Apr Fire Protection Specialist
FABRIC AND RUBBER PRODUCTS 58	58010 Fabric & Rubber Products Helper	58230 Apr Fabric and Rubber Products Specialist 58231 Apr Parachute Rigger
MARINE 59	59010 Marine Helper	59130 Apr Seaman 59131 Apr Marine Engineman
TRANSPORTATION 60	60010 Transportation Helper	60134 Apr Packaging Specialist 60230 Apr Passenger and Household Goods Specialist 60231 Apr Freight Traffic Specialist 60330 Apr Vehicle Operator/Dispatcher 60530 Apr Air Passenger Specialist A In-flight Passenger Service 60531 Apr Air Cargo Specialist
SUPPLY SERVICES 61	61010 Supply Services Helper	61130 Apr Supply Services Specialist 61230 Apr Meatcutter
FOOD SERVICE 62	62010 Food Service Helper	62130 Apr Baker 62230 Apr Cook 62231 Apr Diet Therapy Specialist
FUEL SERVICES 63	63010 Fuel Helper	63130 Apr Fuel Specialist
SUPPLY 64	64010 Supply Helper	64530 Apr Inventory Management Spec A Munitions 64730 Apr Materiel Facilities Spec 64830 Supply Systems Specialist
PROCUREMENT 65	65010 Procurement Helper	65130 Apr Procurement Specialist
ACCOUNTING AND FINANCE, AND AUDITING 67	67010 Accounting and Finance Helper	67230 Budget Specialist 67231 Apr General Accounting Specialist 67232 Apr Disbursement Acctg Specialist 67330 Auditing Specialist

<u>CAREER FIELD</u>	<u>INPUT OR UNSKILLED LEVEL</u>	<u>SEMISKILLED LEVEL</u>
MANAGEMENT ANALYSIS 69	69010 Management Analysis Helper	69130 Apr Management Analysis Specialist
ADMINISTRATION 70	70010 Administration Helper	70130 Apr Chapel Management Specialist 70230 Apr Administration Specialist 70430 Apr Stenographic Specialist 70530 Apr Legal Services Specialist
PRINTING 71	71010 Printing and Duplicating Helper	71130 Apr Duplicating Specialist 71330 Apr Printing-Binding Specialist 71331 Apr Photolithography Specialist
PERSONNEL 73	73010 Personnel Helper	73230 Apr Personnel Specialist 73231 Personal Affairs Specialist 73233 Personnel Sys Mgt Specialist 73234 Career Advisory Specialist 73331 Manpower Management Specialist 73430 Social Actions Specialist A Equal Opportunity B Drug/Alcohol C Race Relations
SPECIAL SERVICES 74	74010 Special Services Helper	74130 Apr Athletic Specialist 74231 Apr Recreation Specialist 74230 Apr Steward Specialist
EDUCATION AND TRAINING 75	75010 Education & Training Helper	75130 Apr Education Specialist 75132 Training Specialist 75133 Instructional System Specialist 75330 Apr Small Arms Specialist 75331 Gunsmith Specialist
INFORMATION 79	79010 Information Helper	79130 Apr Information Specialist A Historian 79131 Apr Radio & TV Broadcasting Specl
SECURITY POLICE 81	81010 Security Police Helper	81130 Apr Security Specialist A Military Working Dog Qualified 81230 Apr Law Enforcement Specialist A Military Working Dog Qualified 81231 Apr Corrections Specialist
SPECIAL INVESTI- GATIONS & COUNTERINTEL- LIGENCE	INPUT FROM ANY CAREER FIELD	82130 Special Investigations & Counter- intelligence Specialist A Technical Investigation

# APPENDIX J - SELECTION MODE FUNCTIONAL CHART

The selection modes (SM) available to the LCOM user are the tools by which he is able to describe the process or flow of maintenance tasks to be simulated. His "description" is then input into the LCOM Input Processor which edits and compresses the information into a format which may be efficiently processed by the LCOM simulation model. The table below describes each of the twelve available SM's, their parameters, uses, and limitations.

SELECTION MODE	SYMBOL	PARAMETERS	FUNCTION	LIMITATIONS/CAUTIONS/REMARKS
1. Non-mutually exclusive task selection.	A	Probabilities of task selection.	To model the case where one or more tasks/paths may emanate from one event or node, where any, all, or none of the paths may be taken.	Some statistical short falls primarily as pertains to the "independence of failures and the fact that possibly none of the paths will be selected. (See Chap. 3, Para. D and SM #7 below) Do not mix separate sets of A, E, or G SMs from the same node.
2. Constrained Task	B	N/A	To constrain or hold up the processing of other parallel tasks in the same network node.	Not recommended for use since a "C" or call selection mode can accomplish the same result and is not as dangerous.
3. Call	C	The network node to be "called" is placed in the task name field on the Form 11.	Similar to a subroutine call in computer programming. Processing is transferred to the called network section. All tasks in the section must be completed prior to return to the next network node.	Most network constraints should be handled via this selection mode (See "B" SM above.)
4. DO	D	N/A	Once a "D" task is reached in the task network, the task is always executed.	
5. Mutually exclusive	E	Probabilities of task selection (must add to 1.0).	To model the case where one of two or more mutually exclusive tasks/paths is to be selected.	Do not mix separate sets of A,B,& G SMs from the same node.

# APPENDIX J - (Cont'd)

SELECTION MODE	SYMBOL	PARAMETERS	FUNCTION	LIMITATIONS/CAUTIONS/REMARKS
6. Failure	F	<p>a. "Clocks" whose value may be a constant or any of the distributions referred to on page 3-3 (corrected) of the original users manual. These clocks may be decremented (count down) by flight hours, sorties, or a pure number.</p> <p>b. The model also allows a special "dummy" clock to be used. Dummy clocks are used to string/link together all or portions of the task networks back to a common node(s).</p>	<p>a. Allow the "opening" or processing of a failed or selected network paths by opening a "gate" which allows the network tasks associated with the failed part to be processed.</p> <p>b. The function of dummy clocks is to allow entry into a large set of task networks at a few nodes. This convenience simplifies entry into the task networks because the failure of a real failure clock will automatically string backwards to the common node by opening the gates controlled by the dummy clocks.</p>	<p>a. Failure clocks will not string backwards through a call selection mode task (#3 above).</p> <p>b. Attempting to string two F tasks back from one common mode will not work as the input model will "over write" the first task when attempting to string the second task.</p>
7. "Get" at least one non-mutually exclusive task.	G	<p>Probabilities of task selection (See "A" selection above.)</p>	<p>To model the case where one or more tasks/paths may emanate from one event or node, and one or more must be taken.</p>	<p>More statistically correct than "A" selection mode but more in computer run times. (See Chap 3, para. D &amp; #1 above). Do not mix, separate sets of A,E, or G SMs from the same node.</p>

# APPENDIX J - (Cont'd)

SELECTION MODE	SYMBOL	PARAMETERS	FUNCTION	LIMITATIONS/CAUTIONS/REMARKS
8. Halt	H	Same as F except no "dummy" Hs are allowed.	Reverse of F above, i.e., ability to close or shut off a task or path.	Do not place an "H" task directly between a mission entry point and a sortie task, i.e., must be able to reach sortie task.
9. Ignore	I	Times of all tasks coded "J" are ignored except when the part associated with the particular I task is cannibalized.	To enhance the realism of the LCOM cannibalization process by showing the amount of time required to cannibalize a part. Large times eliminate parts from consideration.	The "I" task must be the task which makes the supply demand, i.e., one that would be back ordered if no part was available, i.e., a NORS condition.
10. Jump	J	Controlled by the preflight switch, if pre-flight switch (PFS) is on, all tasks with a "J" selection mode are jumped or skipped. If PFS is off "J" tasks default to "D0" tasks.	To allow certain tasks to be accomplished only once daily or any 24-hour period.	A "J" task turns the pre-flight switch "partially on". It is turned "fully on" by subsequently reaching an "S" (sortie) task, or reaching a "K" (kill) task, or reaching the end of the network.
11. Kill	K	Turns the pre-flight switch on immediately.	Turns on the pre-flight switch so that all down stream "J" or "K" tasks are jumped/skipped.	Insure that any K task is networked after all required J tasks.
12. Sortie	S	The sortie takeoff time and length as reflected on LCOM Form 20.	To allow for time constrained tasks associated with a scenario or flying schedule to be controlled and executed.	Sortie tasks cannot require, consume or generate resources. Tasks should not be placed in the network in parallel with the sortie task.

APPENDIX K  
TASK TYPE AND PRIORITY

<u>TYPE</u>	<u>PRIORITY</u>	<u>TASK</u>
1	1	Flying Operation
2	1	System Failures
2	1	Cannibalization Actions
2	2	On-Equipment Unscheduled Maintenance
2	3	Off-Equipment Unscheduled Maintenance
3	2	Phase Inspections
3	1	Preflight Inspections
3	1	Thruflight Inspections
3	2	Postflight Inspections
3	2	Calendar Inspections
5	1	Clock Decrements
5	1	Resupply Delays
5	1	Dummy Tasks

## APPENDIX L

### DIAGNOSTIC CHECKS MADE IN PHASE I (PROCESSING OF EXTENDED FORM 11)

1. Data must be in appropriate numeric format. The system will halt and print an error diagnostic if alpha data appears in any column designated as numeric format.
2. Action and work unit code on a trailer card must match action and work unit code on the preceding card with C in column 80. If it does not, an error is printed and the record is not processed.
3. Only selection modes A, B, C, D, E, F, G, S, or X are accepted. If selection mode is omitted, or any other letter used, an error message is printed and the record is not processed.
4. An A, E, F, or G selection mode must have a non-blank MSBMA or probability value indicated or a warning message is printed.
5. If a record has an F selection mode, work unit code and clock number must match. If not, an error is printed and the record is not processed.
6. If the input record specifies any time or resources when repeating a previously defined task, the program prints a warning. This usually indicates that the same task name was inadvertently used to define two distinctly different tasks.
7. If an asterisk is not found in column 39 for a task with action code W, K, or N the program prints a warning. This does not necessarily indicate an error. There are situations where an N, W, or K card should not have the asterisk, such as bench check on return from depot. The message is a warning to double check and be sure that the omission was intentional.
8. If sequentially encountered E probabilities in the same network segment do not sum to 1.00, the program prints a warning. This is not necessarily an error. If H cards for nomenclature are inserted within a sequence of E probability tasks it will upset the computer's tally and produce a message. However, any time the message appears the preceding E probabilities should be double checked.



APPENDIX M

TIME CONVERSION TABLES

UNDER ONE MINUTE

<u>MINUTES</u>	<u>HOURS</u>	<u>MINUTES</u>	<u>HOURS</u>
.10	.001	.55	.009
.15	.0025	.60	.010
.20	.003	.65	.011
.25	.004	.70	.012
.30	.005	.75	.0125
.35	.006	.80	.013
.40	.007	.85	.014
.45	.0075	.90	.015
.50	.008	.95	.016
		1.00	.017

DECIMAL TIMES

<u>MINUTES</u>	<u>HOURS</u>	<u>MINUTES</u>	<u>HOURS</u>
1	.0166	31	.5166
2	.0333	32	.5333
3	.05	33	.5500
4	.0666	34	.5666
5	.0833	35	.5833
6	.10	36	.6000
7	.1166	37	.6166
8	.1333	38	.6333
9	.150	39	.6500
10	.1666	40	.6666
11	.1833	41	.6833
12	.2000	42	.7000
13	.2166	43	.7166
14	.2333	44	.7333
15	.25	45	.7500
16	.2666	46	.7666
17	.2833	47	.7833
18	.3000	48	.8000
19	.3166	49	.8166
20	.3333	50	.8333
21	.3500	51	.8500
22	.3666	52	.8666
23	.3833	53	.8833
24	.4000	54	.9000
25	.4166	55	.9166
26	.4333	56	.9333
27	.4500	57	.9500
28	.4666	58	.9666
29	.4833	59	.9833
30	.5000	60	1.00

## APPENDIX N

### ACRONYMS

AFSC	-	Air Force Specialty Code
AGE	-	Aerospace Ground Equipment
AMS	-	Avionics Maintenance Squadron
ART	-	Average Repair Time
ATC	-	Action Taken Code
CAMSQ	-	Consolidated Aircraft Maintenance Squadron
CUTIL	-	Cumulative Utilization
FORTTRAN	-	Formula Translation - A Computer Compiler
FMS	-	Field Maintenance Squadron
GO33BNF1A	-	AFLC GO33BNF1R Report, Monthly Aerospace Status (Parts 1, 2, 3)
HQ TAC/LG	-	Headquarters Tactical Air Command, Directorate of Logistics
JEFM	-	Jet Engine Field Maintenance
JEIM	-	Jet Engine Intermediate Maintenance
JCL	-	Job Control Language
JCN	-	Job Control Number
K-97	-	AFLC K-97 Report, Consolidated Maintenance Data
K-18	-	TAC-LGY(M) 7302, Monthly Maintenance Data Analysis
LCOM	-	Logistics Composite Model

LPOST	-	Last Posted
MDC	-	Maintenance Data Collection
MED	-	Management Engineering Detachment
MTBMA	-	Mean Time Between Maintenance Actions
MSBMA	-	Mean Sorties Between Maintenance Actions
NDEM	-	Number of Demands
NORM	-	Not Operationally Ready Maintenance.
NORS	-	Not Operationally Ready Supplies
NRTS	-	Not Repairable This Station
OMS	-	Organizational Maintenance Squadron
PSR	-	Performance Summary Report
RFS	-	Realized Flying Schedule
SBMA	-	Sorties Between Maintenance Action
SIMSCRIPT	-	Computer Simulation Language Developed by Rand, Used in LCOM
TCTO	-	Time Compliance Technical Order
UDL	-	Unit Detail Listing
UE	-	Unit Equipped
USAF/PRM	-	Directorate of Manpower and Organization Headquarters United States Air Force
USAF/SA	-	United States Air Force Assistant Chief of Staff Studies and Analysis
WUC	-	Work Unit Code

APPENDIX 0  
CDC-6600 CONTROL CARDS

All examples of the control cards shown here do not include any phase or accounting cards which must precede these cards. The symbols 7/8/9 and 6/7/8/9 represent a 7-8-9 and a 6-7-8-9 multipunch in column one respectively.

a. Data Base Generator (DBG)

The Data Base Generator is the CDC system UPDATE. The control cards are shown in Fig. 0-1. The user inserts the coded Extended Forms 11 after the \*DECK DBASE card indicated in the figure.

b. Data Base Updating (DBU)

Each time a data base is generated or updated a listing is produced. To the right of each card in the listing is a name (normally it will be DBASE OR FDATA) followed by a number.

1. Insertions

Cards are inserted into the data base by preceding them with a card which has a \*I in columns 1-2 followed by the name and number beginning in column 4 and separated by a period.

Example: Suppose the user wishes to insert some cards after a card in the data base which was identified by DBASE 212 in the listing. The following modification cards would accomplish this.

\*I DBASE.212  
card to be added

## 2. Deletions and Replacements

Any card in the data base may be deleted by putting a card in the modification input which has a \*D in columns 1-2 and the identifying name and number beginning in column 4. Any cards which follow this card will replace the deleted card. Example: If we consider the following modification:

```
*I DBASE .123
Card 1
Card 2
*D DBASE .015
Card 3
Card 4
*D DBASE .142
```

then card 1 and 2 would be inserted in the data base after the card which that the label DBASE 123 in the listing. Cards 3 and 4 would replace the card labeled DBASE 105 in the data base testing, and the card labeled DBASE 142 would be deleted from the data base.

### c. Phase I Part 1

The control cards for use of the data base updating (DBU) programs and Phase I part 1 (P1) is shown in Figure 0-3. The 'name' and 'identification' is the same as given in the data base generation.

### d. Phase I Part 1,2 and auxiliary programs.

The control cards for the entire Phase I processes is shown in Fig. 0-4. If there are additional modifications, they may be inserted in the control deck where indicated. Still 'name' and 'identification' identify the particular data base.

e. The ZAP Run

The control cards to run the input model from the FDATA are shown in Fig. 0-5.

f. The Operation Data Production

The control cards which will convert the LCOM Forms 15 and 20 into an operation data file are shown in Fig. 0-6.

g. Moody Manpower Regression Program

Figure 0-7 shows a sample set of control cards for running the regression program entirely from cards. Figure 0-8 shows control cards for running the regression program from a permanent file named REGPNCH.

h. Moody Manpower Program

The sample control cards for running the Moody Manpower Program are shown in Figs. 0-9 through 0-11. Figure 0-9 assumes the TAPE8 file and the FORTRAN are on permanent file named ACH16CDK. Figure 0-10 shows a run entirely from cards. Finally, 0-11 shows a run where the compiled program is on a permanent file MANPOWER, the TAPE8 file is on file ORGANIZATION, the TAPE2 file is on permanent file COEFFICIENTS, and the input is on cards.

```

REQUEST(NEWPL,*PF)    - Get space for DBASE
UPDATE(F,N,L=A5)      - Generate updatable file
CATALOG(NEWPL,'name',CY=1,RP=999,ID='identification') - Save the file
7/8/9
*DECK DBASE - DBASE identifier
Extended Forms 11 cards
6/7/8/9

```

Figure 0-1.  
Data Base Generator (DBG)

```

REQUEST(NEWPL,*PF)    - Get space for updated DBASE
ATTACH(OLDPL,'Name',CY=1,ID='identification') - Get old DBASF
UPDATE(F,N,L=A5)      - Update the file
CATALOG(NEWPL,'name',RP=999,ID='identification') - Save new DBASE file
PURGE(OLDPL)          - Purge old DBASE file
RENAME(NEWPL,CY=1)    - Set new DBASE file to cycle
7/8/9
*ID 'unique name'
modifications to data base
6/7/8/9

```

Figure 0-2.  
Data Base Update (DBU)

```

REQUEST(NEWPL,*PF)    - Get space for update DBASF
ATTACH(OLDPL,'name',CY=1,ID='identification') - Get old DBASF
UPDATE(F,N,D,8,L=A5)  - Update the file
CATALOG(NEWPL,'name',RP=999,ID='identification') - Save the new file
PURGE(OLDPL)          - Purge old DBASE file
RENAME(NEWPL,CY=1)    - Set new DBASE file to cycle 11
ATTACH(P1,FASIP1B,CY=1,ID=AFTEC) - Get Phase 1, Part 1
RETURN(OLDPL,NEWPL)   - Return use of DBASE
P1(PL=100000,COMPILE) - Run PHASE1 PART1
7/8/9
*ID 'unique name'
modifications to data base
6/7/8/9

```

Figure 0-3.  
Phase I Part 1 Run



```

REQUEST(NEWPL,*PF)
ATTACH(OLDPL,'name',ID='identification')
UPDATE(F,N,D,8,L=A5)
CATALOG(NEWPL,'name',RP=999,ID='identification')    - Same as 0-3
PURGE(OLDPL)
RENAME(NEWPL,CY=1)
RETURN(NEWPL,OLDPL)    - Return use of Part 11
ATTACH(P1,FASIP1B,CY=1,ID=AFTEC)    - Get Phase 1, Part 2
P1(PL=10000,COMPILE)    - Position output from Part 1
RETURN(P1)
ATTACH(P2,FASIP2B,CY=2,ID=AFTEC)    - Define files
REWIND(NTWB)
FILE(NTWB,FO=SQ,BT=C,RT=Z,FL=80)
FILE(NTWDA,FO=SQ,BT=C,RT=Z,FL=80)
FILE(FHOLD,FO=SQ,BT=C,RT=Z,FL=80)
LDSET(FILES=NINKB/NTWDA/FHOLD)
P2.
RETURN(P2)    - Run Part 2
REWIND(NTNDA)    - Return use of Part 2
REQUEST(NEWPL,*PF)    - Get space for maintenance input
UPDATE(F,N,I=NTWDA,L=A5)    - Generate maintenance input file
CATALOG(NEWPL,'name',CY=2,RP=999,ID='identification')    - Save file
REWIND(FHOLD)    - Positive output for Part 2
ATTACH(P12,FBIN127,CY=1,ID=AFTEC)    - Get first auxiliary program
P12.    - Run first auxiliary program
RETURN(P12)
REWIND(TAPE2)
SORTMRL(6C)
REWIND(TAPE22)
COPYSBF(TAPE22,OUTPUT)    - Sort output from first auxiliary program
REWIND(TAPE22)
ATTACH(PCD,FBINCDZ,CY=1,ID=AFTEC)    - Run second auxiliary program
PCD.
7/8/9
*ID 'unique name'
      modification to FDATA data base
7/8/9
SORT(1,1,30,,4)
FILE(TAPE2,S,D,,R,N)
FILE(TAPE22,O.D,,R,N)
KEY(A,C,1,20)    - Sorting directives
RECORD(T,U,30)
END
6/7/8/9

```

Figure 0-4.  
Entire Phase I Run.

```

REQUEST(NEWPL,*PF)      - Get space for update of maintenance file
ATTACH(OLDPL,'name',CY=2,ID='identification')  - Get old maintenance data file
UPDATE(F,N,D,8,C=TAPE1,L=A5)
CATALOG(NEWPL,'name',RP=999,ID='identification') - Save new file
PURGE(OLDPL)
RENAME(NEWPL,CY=2)
RETURN(OLDPL,NEWPL)
ATTACH(IPXEQ,LCOMIP,CY=1,ID=AFTEC)              - Get LCOM input model
ATTACH(TAPE5,LCOMIP,CY=2,ID=AFTEC)              - Get model initialization file
ATTACH(TAPE9,*PF)                                - Get space for maintenance input file
REQUEST(TAPE9,*PF)
RFL(200000)
IPXEQ(PL=200000)                                - Run input model
REDUCE.
CATALOG(TAPE9,'name',CY=3,RP=999,ID=AFTEC)      - Save maintenance input file
7/8/9
*ID 'unique name'
      modifications to FDATA data base
7/8/9
EQUIP,1 = TAPE1
EQUIP,6 = OUTPUT
EQUIP,7 = TAPE7
EQUIP,9 = TAPE9
1x      117      5
6/7/8/9

```

Figure 0-5  
Creation of Maintenance Input File (LAP Run)

```

ATTACH(IPXEQ,LCOMIP,CY=1,ID=AFTEC)              - Get LCOM input model
ATTACH(TAPE5,LCOMIP,CY=2,ID=AFTEC)              - Get input model initialization fil
REQUEST(TAPE7,*PF)                                - Get space for operation data file
RFL(200000)
IPXEQ(PL=20000)
REDUCE.
CATALOG(TAPE7,'name',CY=4,RP=999,ID=AFTEC)      - Save operation data file
7/8/9
EQUIP,1=INPUT
EQUIP,6=OUTPUT
EQUIP,5=TAPE5
EQUIP,7=TAPE7
EQUIP,9=TAPE9
1X      117      5
      LCOM Forms 16 and 20
999999
6/7/8/9

```

Figure 0-6.  
Creation of Operation Data File.

FTN	- Compile regression program.
LDSET(MAP=0)	- Turn off load map.
LGO.	- Execute regression program.
7/8/9	
'FORTRAN of Regression Program'	
7/8/9	
Input File 1	
7/8/9	
Input File 2	
6/7/8/9	

Figure 0-7  
Regression Program (from cards)

ATTACH(REG,REGPNCH,ID='identification')	- Get regression program.
LDSET(MAP=0)	- Turn off load map.
REG.	- Execute regression program.
7/8/9	
Input File 1	
7/8/9	
Input File 2	
6/7/8/9	

Figure 0-8  
Regression Program (from Personnel file)

ATTACH(T,ACF16CDK,ID='identification')	- Get TAPE8 and FORTRAN.
COPYBR(T,TAPE8)	- Set up TAPE8 File.
REWIND(TAPE8)	
COPYBR(INPUT,TAPE2)	- Get TAPE2 file from INPUT
REWIND(TAPE2)	
FIN(I=t)	- Compile Manpower Program
LGO.	- Execute Manpower Program
7/8/9	
'TAPE2 file'	
7/8/9	
'INPUT file'	
6/7/8/9	

Figure 0-9  
Manpower Program  
(TAPE8 and FORTRAN on Permanent File)

FTN.	
COPYBR(INPUT,TAPE2)}	- Compile Manpower Program
REWIND(TAPE2)}	- Get TAPE2 file.
COPYBR(INPUT,TAPE8)}	- Get TAPE8 file from input.
REWIND(TAPE8)}	- Run Manpower program.
LGO.	
7/8/9	
'FORTRAN of Manpower Program'	
7/8/9	
'TAPE2 File'	
7/8/9	
'TAPE2 File'	
7/8/9	
'INPUT File'	
6/7/8/9	

Figure 0-10  
Manpower Program  
(from cards)

ATTACH(MANPWR,MANPOWER,ID='identification')	- Get Manpower Program.
ATTACH(TAPE8,ORGANIZATION,ID='identification')	- Get TAPE8 File.
ATTACH(TAPE2,COEFFICIENTS,ID='identification')	- Get TAPE2 File.
MANPWR.	- Run Manpower Program.
7/8/9	
'INPUT File'	
6/7/8/9	

Figure 0-11  
Manpower Program  
(from Permanent File)

## APPENDIX P

### HONEYWELL 6000 CONTROL CARDS

The Phase I processor is not used on the Honeywell 6000; therefore, the user must generate the LCOM Forms 11, 12, 13 and 14 directly as well as the other forms and submit them directly to the input model.

#### (a) Input Model

The control cards for the input model are shown in Figure P-1.

##### (1) Description of the Files

PRMFL	04	The input LCOM data (04 may be defined other ways besides a permanent file).
PRMFL	07	The maintenance input file. This is the same as the LCOM initialization file (can also be defined in other ways).
PRMFL	17 27	Output files for task and resource names.
FILE	09	This is the output for the operation data file (the exogenous file). It must be sane in some manner to be used.

#### (b) LCOM Simulation

The control cards for simulation are shown in Fig. P-2 . The change cards are inserted as shown in the figure. The files the user will initially need are:

PRMFL	07	The initialization file (the maintenance input).
PRMFL	09	The exogenous file (the operation data file).
FILE	11	Output files for manpower matrix, realized flying
	12	schedule, parts failure, and line diagnostics
	15	respectively.
	16	

```

$ OPTION FORTRAN
$ LOWLOAD 20
$ LIBRARY SL
$ SELECT LCOM/OINPTCT
$ SELECT LCOM/OINPLJPL
$ EXECUTE
$ LIMITS 35,104K,-1K,20K
$ PRMFL 03,R,L,LCOM/3INPINT7
$ PRMFL 04,R,L,LCOM/F1DDAD
$ PRMFL 07,W,L,LCOM/F1DINT3
$ PRMFL 17,W,L,LCOM/F1DTASK
$ PRMFL 27,W,L,LCOM/F1DRES
$ PRMFL 37,W,L,LCOM/F1DPLOT
$ PRMFL 08,R,L,LCOM/3DUMINSA
$ FILE 08,X1R,5L
$ PRMFL SL,R,L,LCOM/OSIMLIB
L 1 145 4 8 3 XX
FINISH
ENDSIM
$ ENDJOB

```

Figure P-1.

```

$ OPTION FORTRAN
$ LOWLOAD 20
$ LIBRARY SL
$ SELECT LCOM/OMAINSA4
$ EXECUTE
$ LIMITS 250,115K,-1K,20K
$ FILE 03,NULL
$ FILE 04,NULL
$ PRMFL 07,R,L,LCOM/F1DINT1
$ FILE 08,X8R,1L
$ PRMFL 09,R,L,LCOM/F1DEXG24
$ FILE 11,X11S,300L
$ FILE 12,NULL
$ FILE 15,NULL
$ PRMFL 16,W,L,LCOM/F1DTMD2
$ PRMFL SL,R,L,LCOM/OSIMLIB
L 114 7 9 XXX
ENDSIM
$ DATA 10

SIMULATION CHANGES CARDS

$ ENDJOB

```

Figure P-2.

## APPENDIX Q

### GLOSSARY

#### AGGLOMERATE

To gather into a ball, mass, or cluster.

#### ALLOWANCE

A time increment included in the standard time for an operation to compensate the workman for production lost due to fatigue, personal rest and/or unavoidable delays.

#### ASSIGNED TIME

See Time

#### AVAILABILITY

A measure of the degree to which an item is in the operable and committable state at the start of the mission, when the mission is called for at an unknown (random) point in time.

#### BACKLOG

An accumulated workload not yet accomplished.

#### CAPABILITY

A measure of the ability of an item to achieve mission objectives given the conditions during the mission.

#### CHECKOUT

Tests or observations of an item to determine its condition or status.

#### DEBUGGING

A process to detect and remedy inadequacies, preferably prior to operational use.



#### DELAY ALLOWANCE

A time increment included in a time standard to compensate for unavoidable delays.

#### DEPENDABILITY

A measure of the item operating condition at one or more points during the mission, including the effects of Reliability, Maintainability and Survivability, given the item condition(s) at the start of the mission. It may be stated as the probability that an item will (a) enter or occupy anyone or its required operational modes during a specified mission, (b) perform the functions associated with those operational modes.

#### DOWNTIME

See Time, Down.

#### FAILURE

The inability of an item to perform within previously specified limits.

#### FAILURE ANALYSIS

The logical systematic examination of an item or its diagram(s) to identify and analyze the probability, causes, and consequences of potential and real failures.

#### FAILURE, DEPENDENT

One which is caused by the failure of an associated item (s).

Not independent.

#### FAILURE, INDEPENDENT

One which occurs without being related to the failure of associated items. Not dependent.

#### FAILURE, RANDOM

Any failure whose occurrence is unpredictable in an absolute sense but which is predictable only in a probabilistic or statistical sense.

#### FAILURE RATE

The number of failures of an item per unit measure of life (cycles, time, miles, events, etc., as applicable for the item).

#### FRACTIONAL MANNING

The manning required to accomplish a specific workload, expressed in fractional parts of whole persons, i.e. 1.438, 9.219, etc.

#### INHERENT

Achievable under conditions, generally derived by analysis, and potentially present in the design.

#### INPUT TEAM

A management engineering team designated to participate in the measurement phase of a study by collecting input data.

#### INVENTORY, ACTIVE

That group of items assigned an operational status.

#### INVENTORY, INACTIVE

That group of items being held in reserve for possible future commitment to the operational inventory.

#### ITEM

(See MIL-STD-280)

#### ITEM, INTERCHANGEABLE

One, which (1) possesses such functional and physical characteristics as to be equivalent in performance, reliability, and maintainability, to another item of similar or identical purpose; and (2) is capable of being exchanged for the other item (a) without selection for fit or performance, and (b) without alteration of the items themselves or of adjoining items, except for adjustment.

#### ITEM, REPLACEABLE

One which is interchangeable with another item, but which differs physically from the original item in that the installation of the replaceable item requires operations such as drilling, reaming, cutting, filing, shimming, etc., in addition to the normal application and methods of attachment.

#### ITEM, SUBSTITUTE

One which possesses such functional and physical characteristics as to be capable of being exchanged for another only under specified conditions or for particular applications and without alteration of the items themselves or of adjoining items.

#### MAINTAINABILITY

A characteristic of design and installation which is expressed as the probability that an item will be retained in or restored to a specified condition within a given period of time, when the maintenance is performed in accordance with prescribed procedures and resources.

#### MAINTENANCE

All actions necessary for retaining an item in or restoring it to a specified condition.

#### MAINTENANCE, CORRECTIVE

The actions performed, as a result of failure, to restore an item to a specified condition.

#### MAINTENANCE, PREVENTIVE

The actions performed in an attempt to retain an item in a specified condition by providing systematic inspection, detection and prevention of incipient failure.

#### MAN-FUNCTION

The function allocated to the human component of a system.

#### MEAN-MAINTENANCE-TIME

The total preventive and corrective maintenance time divided by the total number of preventive and corrective maintenance actions during a specified period of time.

#### MEAN-TIME-BETWEEN-FAILURES (MTBF)

For a particular interval, the total functioning life of a population of an item divided by the total number of failures within the population during the measurement interval. The definition holds for time, cycles, miles, events, or other measure of life units.

#### MEAN-TIME-BETWEEN-MAINTENANCE

The mean of the distribution of the time intervals between maintenance actions (either preventive, corrective, or both).

#### MEAN-TIME-TO-REPAIR (MTTR)

The total corrective maintenance time divided by the total number of corrective maintenance actions during a given period of time.

#### OPERATIONAL

Of, or pertaining to, the state of actual usage.

#### PREDICTED

That which is expected at some future date, postulated on analysis of past experience.

#### PROGRAM ESTIMATING EQUATION (PEE)

A mathematical equation that uses broadly based, program-oriented, independent variable(s) to forecast manpower requirements into future time periods.

#### READY RATE, OPERATIONAL (COMBAT)

Percent of assigned items capable of performing the mission or function for which they were designed, at a random point in time.

#### RELIABILITY

The probability that an item will perform its intended function for a specified interval under stated conditions.

#### REPAIR

See Maintenance, Corrective

#### SERVICEABILITY

A measure of the degree to which servicing of an item will be accomplished within a given time under specified conditions.

#### SERVICING

The replenishment of consumables needed to keep an item in operating condition, but not including any other preventive maintenance or any corrective maintenance.

#### STANDARD

Any established or accepted rule, model or criterion against which comparisons are made.

#### STORAGE LIFE (SHELF LIFE)

The length of time an item can be stored under specified conditions and still meet specified requirements.

#### SURVIVABILITY

The measure of the degree to which an item will withstand hostile man-made environment and not suffer abortive impairment of its ability to accomplish its designated mission.

#### SYSTEM EFFECTIVENESS

A measure of the degree to which an item can be expected to achieve a set of specific mission requirements, and which may be expressed as a function of availability, dependability and capability.

TIME, ACTIVE

That time during which an item is in the operational inventory.

TIME, ADJUSTMENT OR CALIBRATION

That element of Maintenance Time during which the needed adjustments or calibrations are made.

TIME, ADMINISTRATIVE

Those elements of Delay Time that are not included in Supply Delay Time.

TIME, ALERT

That element of Up-time during which an item is thought to be in specified operating condition and is awaiting a command to perform its intended mission.

TIME, ASSIGNED

Assigned Time. The normal duty hours prescribed for an individual while assigned to a military unit.

TIME, AVAILABLE

Assigned manhours dedicated to the performance of primary duties plus time specifically allowed for person, rest, delay standby and/or transient time.

TIME, CHECKOUT

That element of Maintenance Time during which performance of an item is verified to be in specified condition.

TIME, CLEAN-UP

That element of Maintenance Time during which the item is enclosed and extraneous material not required for operation is removed.

TIME, DELAY

That element of Downtime during which no maintenance is being accomplished on the item because of either supply delay or administrative reasons.

TIME, DOWN (DOWNTIME)

That element of time during which the item is not in condition to perform its intended function.

TIME, FAULT CORRECTION

That element of Maintenance Time during which a failure is corrected by (a) repairing in place; (b) removing, repairing, and replacing; or (c) removing and replacing with a like serviceable item.

TIME, FAULT LOCATION

That element of Maintenance Time during which testing and analysis is performed on an item to isolate a failure.

TIME, INACTIVE

That time during which an item is in reserve (in the Inactive Inventory).

TIME, MISSION

That element of Up-time during which the item is performing its designated mission.

TIME, MODIFICATION

The time necessary to introduce any specific change(s) to an item to improve its characteristics or to add new ones.

TIME, PREPARATION

That element of Maintenance Time needed to obtain the necessary test equipment and maintenance manuals, and set up the necessary equipment to initiate fault location.

#### TIME REACTION

That element of Up-time needed to initiate a mission measured from the time the command is received.

#### TIME, SUPPLY DELAY

That element of Delay Time during which a needed item is being obtained from other than the designated organizational stockrooms.

#### TIME, TURN-AROUND

That element of Maintenance Time needed to service or checkout an item for recommitment.

#### TIME, UP (UP-TIME)

That element of Active Time during which an item is either alert, reacting, or performing a mission.

#### WEAROUT

The process of attrition which results in an increase of the failure rate with increasing age (cycles, time, miles, events, etc., as applicable for the item).



APPENDIX R  
LCOM DISTRIBUTIONS

<u>DIST</u>	<u>TYPE OF DISTRIBUTION</u>	<u>MEAN</u>	<u>MEANING ON LCOM FORMS OF VARIANCE</u>
N	Normal	Statistical Mean	Standard Deviation
P	Poisson	Statistical Mean	N/A
L	Log Normal	Statistical Mean	Standard Deviation
X	Exponential	Statistical Mean	Threshold Constant
B	Bernoulli (1)	Threshold Constant	
		Statistical Mean	N/A
C	Constant	Constant Value	N/A
E	Erland (2)	Statistical Mean	Shape Parameter
W	Weibull (3)	Scale Parameter	Shape Parameter
T	Triangular	(4)	

- (1) Input Model only (Form 20).  
 (2) Implied Threshold of Zero.  
 (3) Main Model only (Forms 12, and 13).  
 (4) Triangular Distribution Parameters on the LCOM Forms are:

T Dist. Parameter	Field Name	Columns on Form 12	Columns on Form 13	Columns on Form 20
Optimistic	mean	15-20	36-41	41-46
Most Likely	Variance	21-26	42-47	47-52
Pessimistic	Optional	65-70	50-55	75-80*

\* Sorry, no sequence numbers permitted on those form 20 cards using the T Distribution.

- (5) Phase I selects X distribution for all failure clock value when processing Extended Forms 11.